Factory Considerations for High Volume Manufacturing using 300 mm wafers

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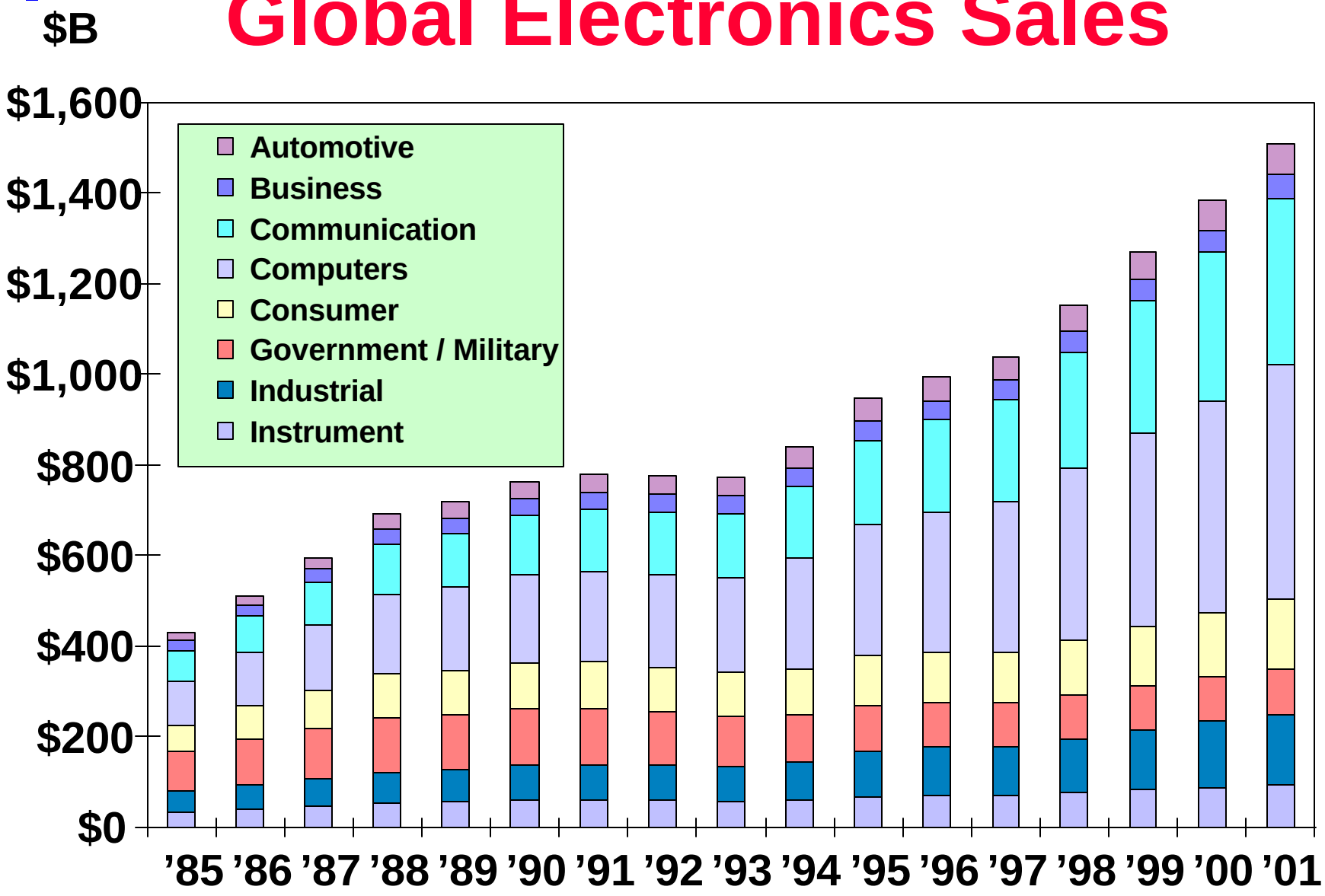
Agenda

- Industry outlook
- 200mm wafer experience
- 300mm wafer conversion
- Equipment cost/productivity goals
- Material handling standardization
- Inter-operability
- Bay layout options
- Factory layout options
- Global cooperation
- Conclusions

Global Electronics Sales



Source: Electronic Outlook Corp. Q3'97

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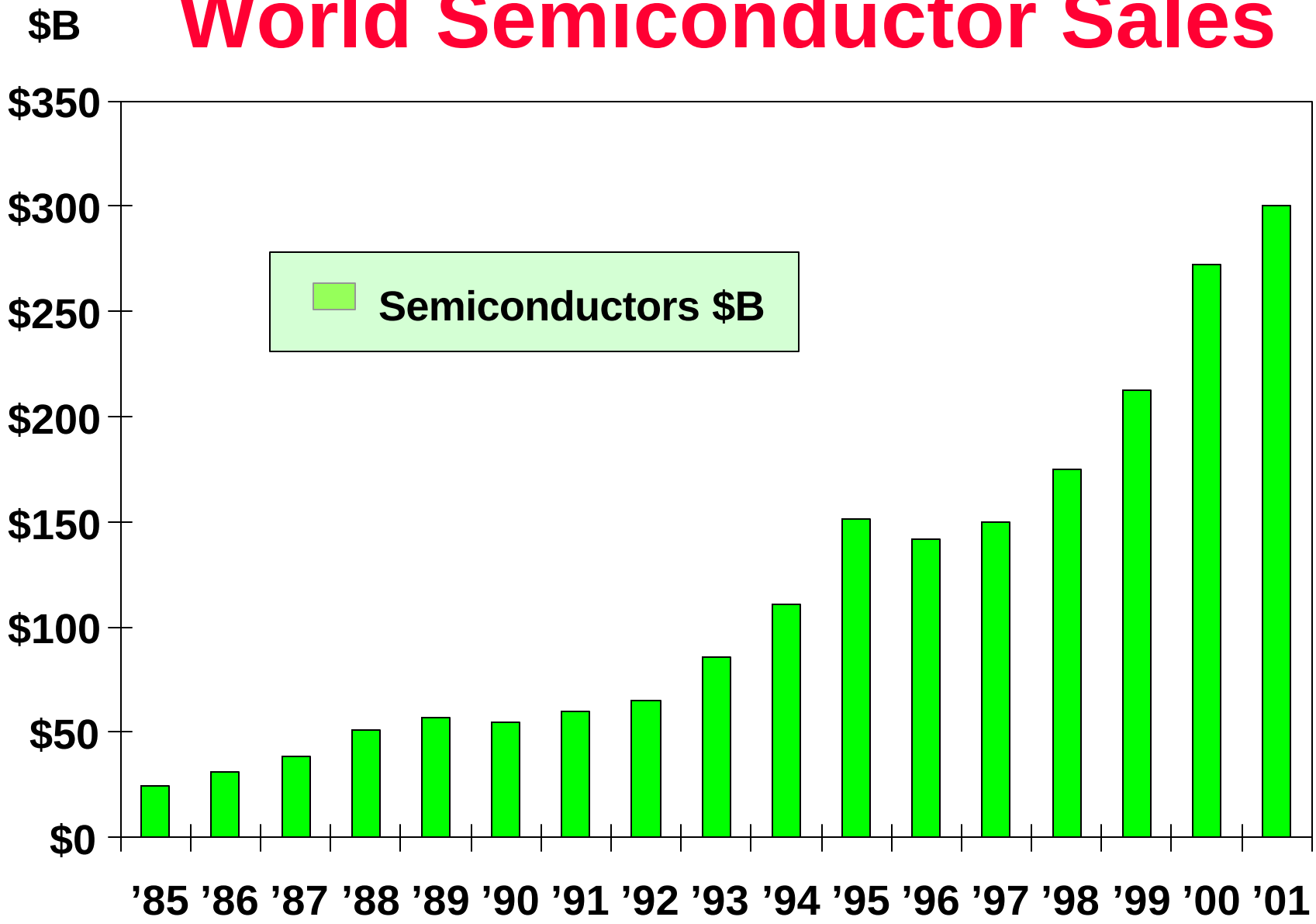
World Semiconductor Sales



Source: Dataquest 9'97

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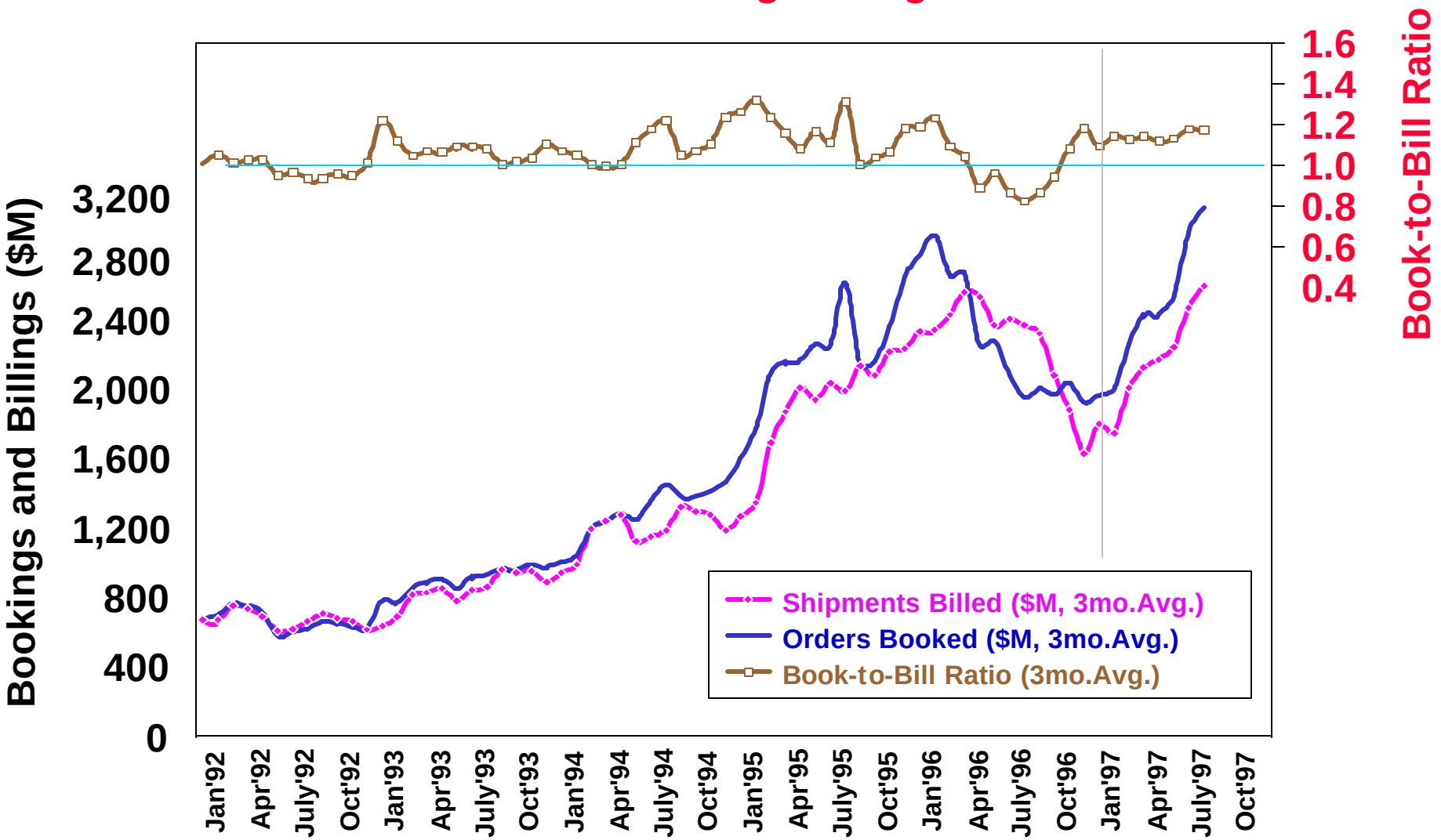
Semi Equipment Sales

3-month rolling average



Source: Semiconductor Equipment and Materials International (SEMI) 10'97

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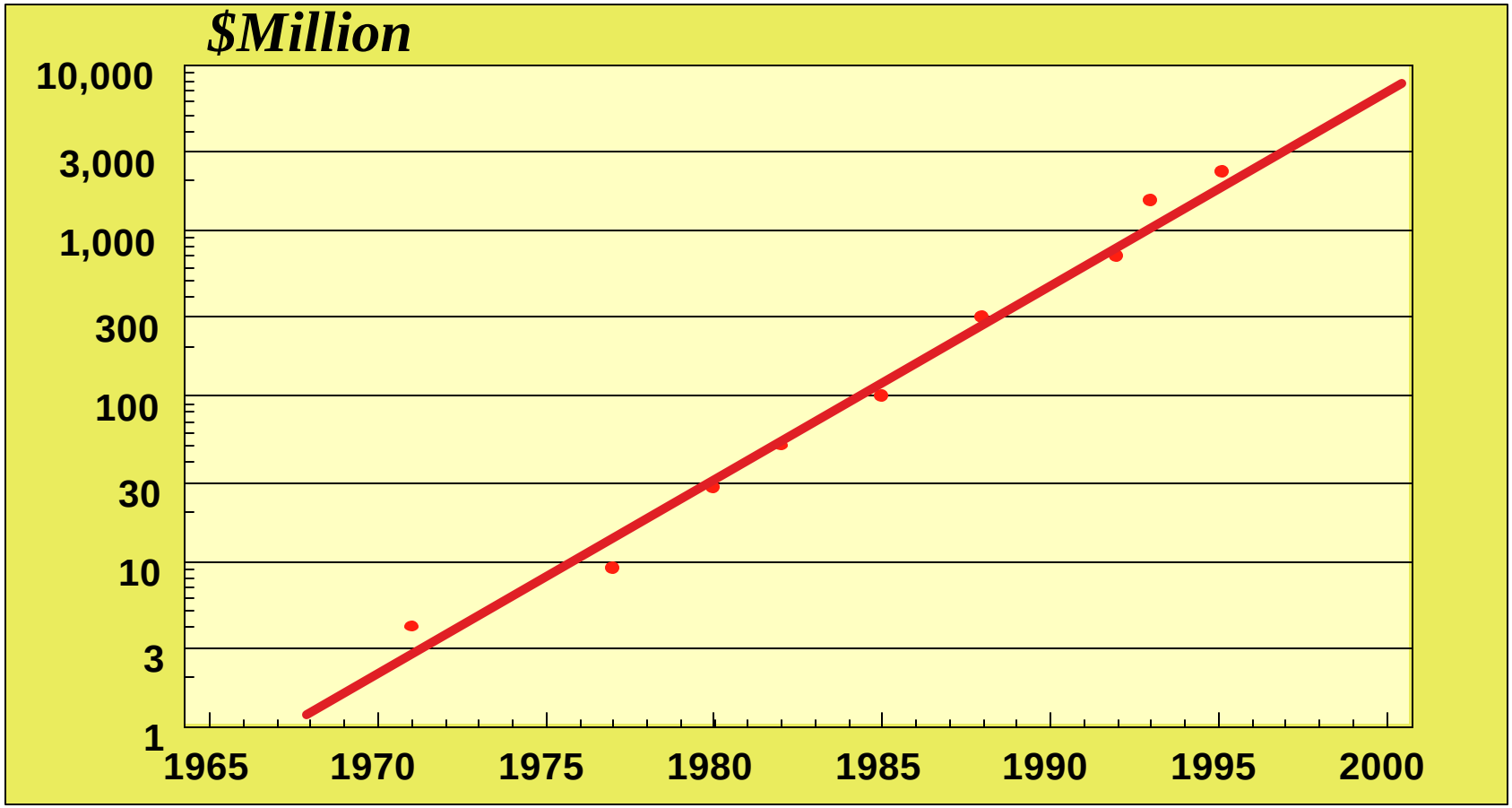
Escalating Cost of Semiconductor Wafer Fabrication Plants



Source: *VLSI Research, Inc.*

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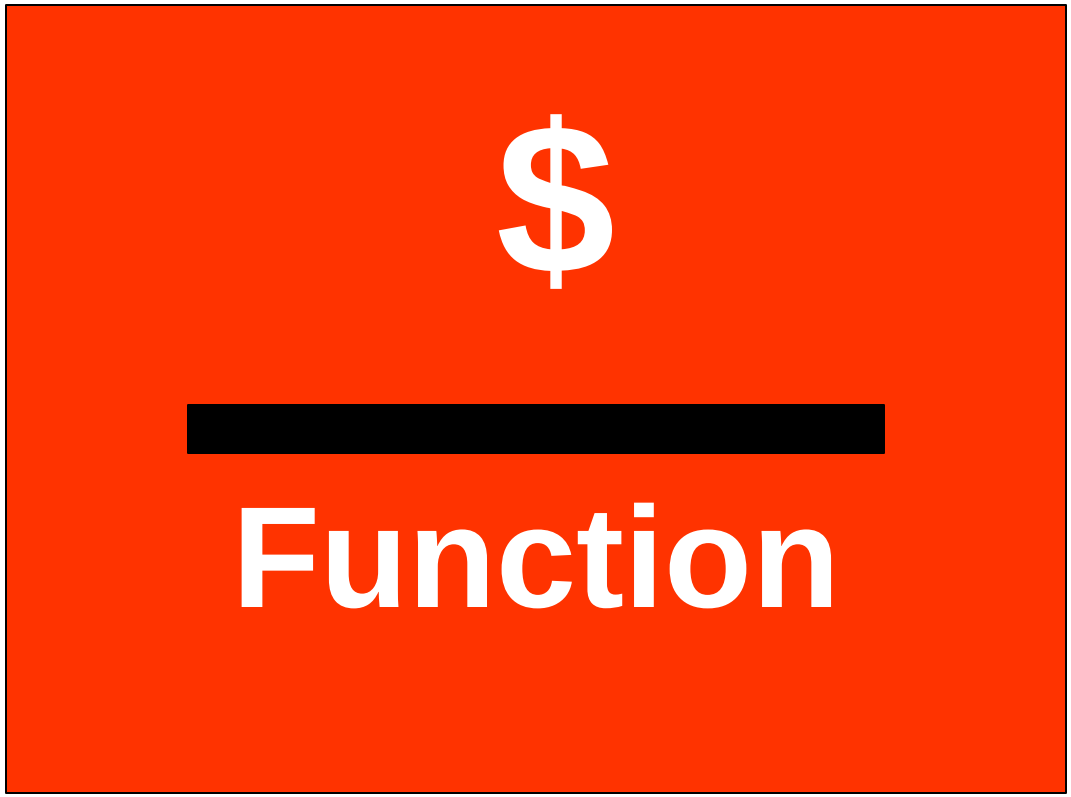
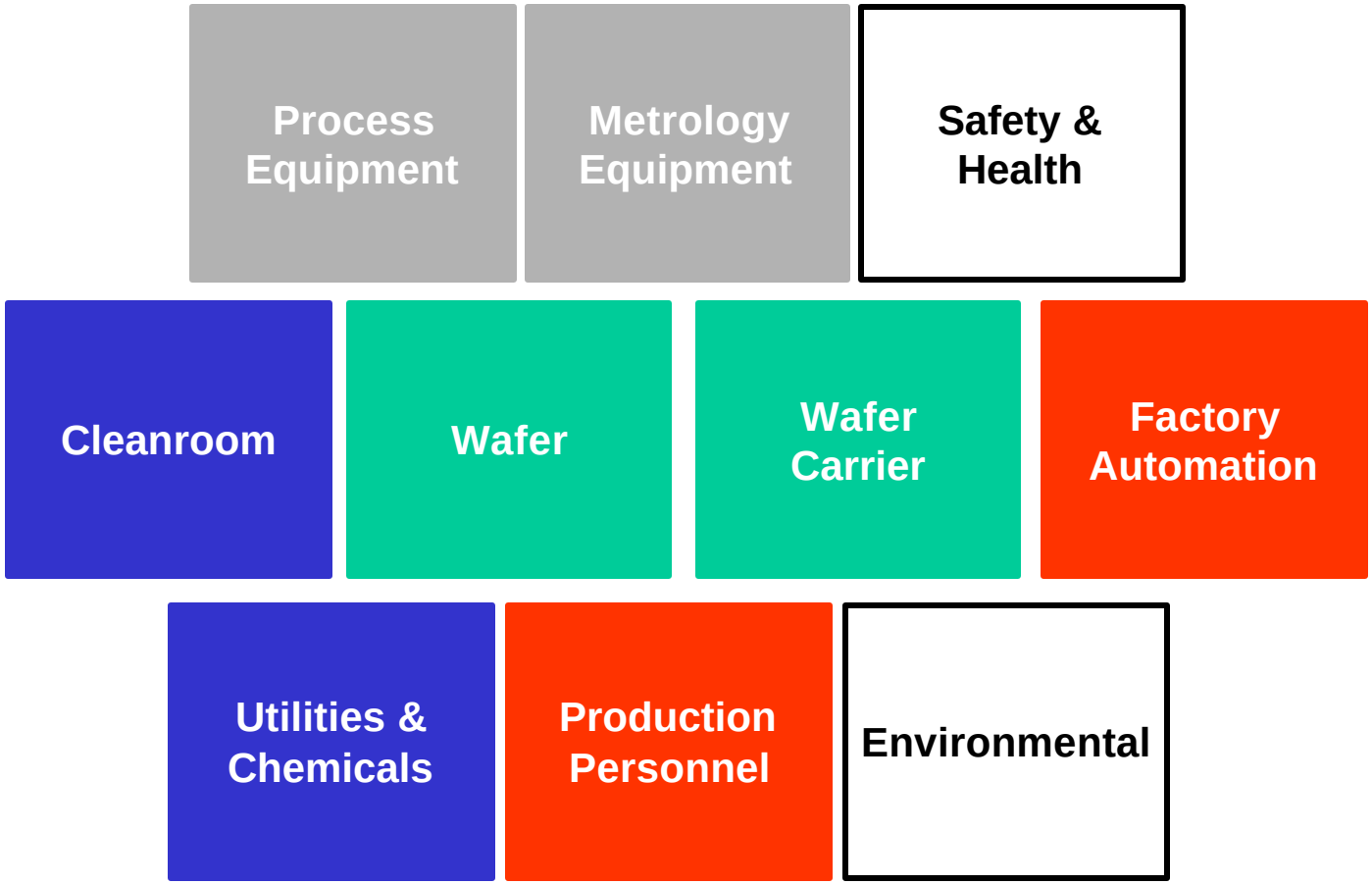
The Key Indicator:
Cost/Function



Cost reduction needs to come from all these components while preserving Safety/Health and the Environment



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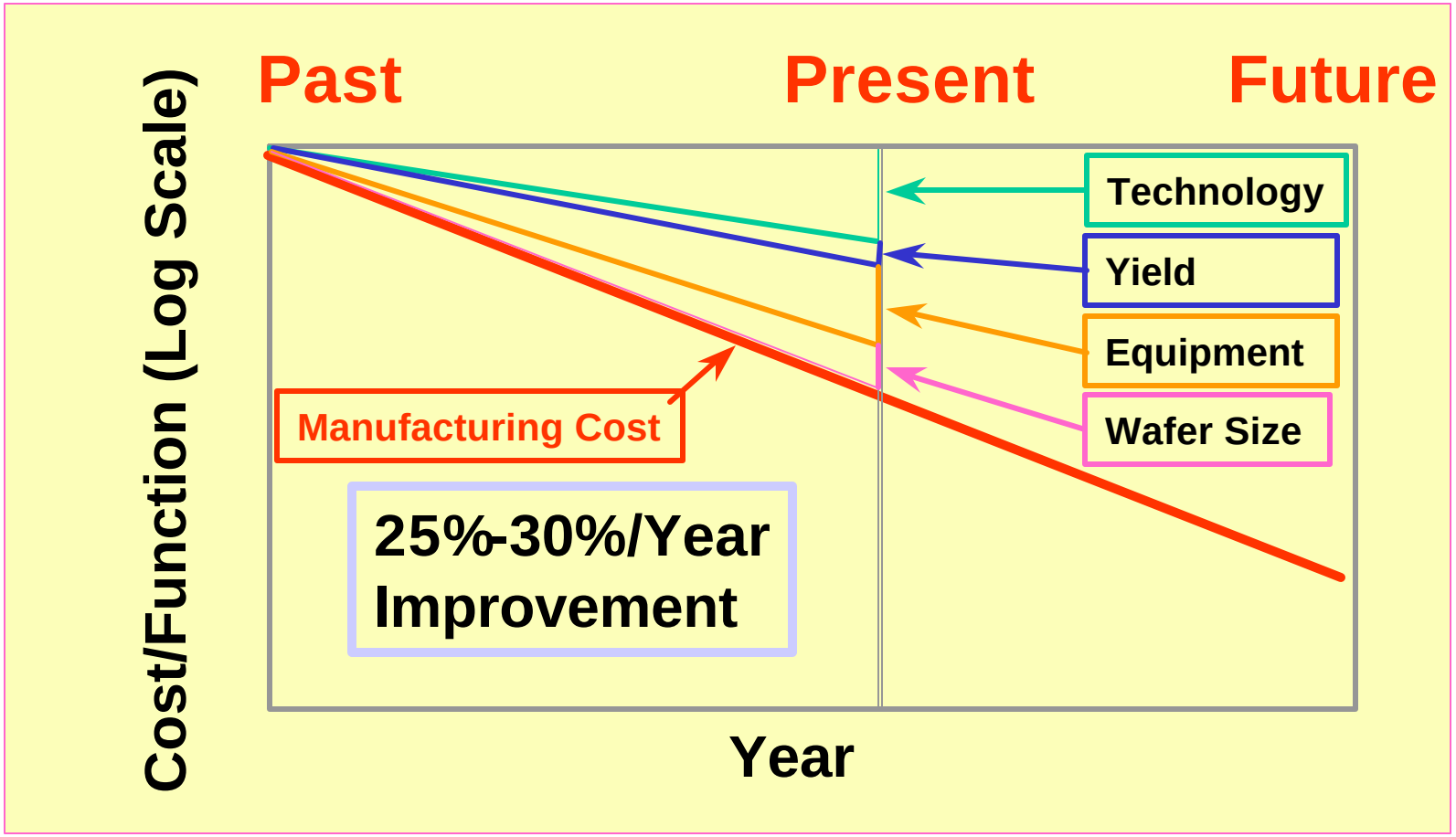
The Cost Reduction Engine



Looking Back at 200mm wafer conversion

- In the 200mm conversion the semiconductor industry missed the opportunity to take advantage of the standardization process
- In the 200mm process and metrology equipment, although the E15 load port standard existed, there was no drive by the IC manufacturers to request tool makers to adhere to this standard.

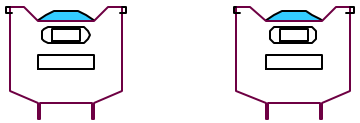
Consequently,

- ☞ Tool makers did not adhere to load port heights nor to cassette orientations
- ☞ Loading and Unloading of tools either by manual systems or automated systems were complicated and costly

There is no Standardization

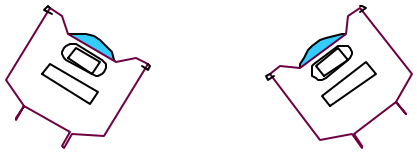
for 200mm Equipment Load port orientation

Tool plan view



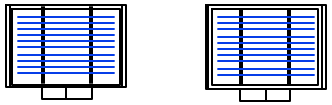
Tool plan view

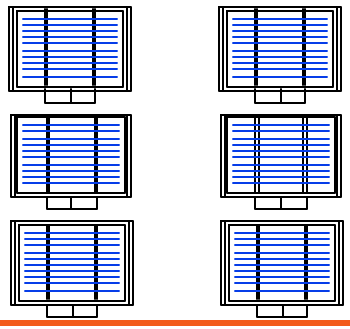
Tool plan view



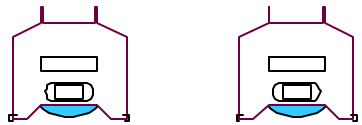
Each tool is different!

Tool plan view





Tool plan view



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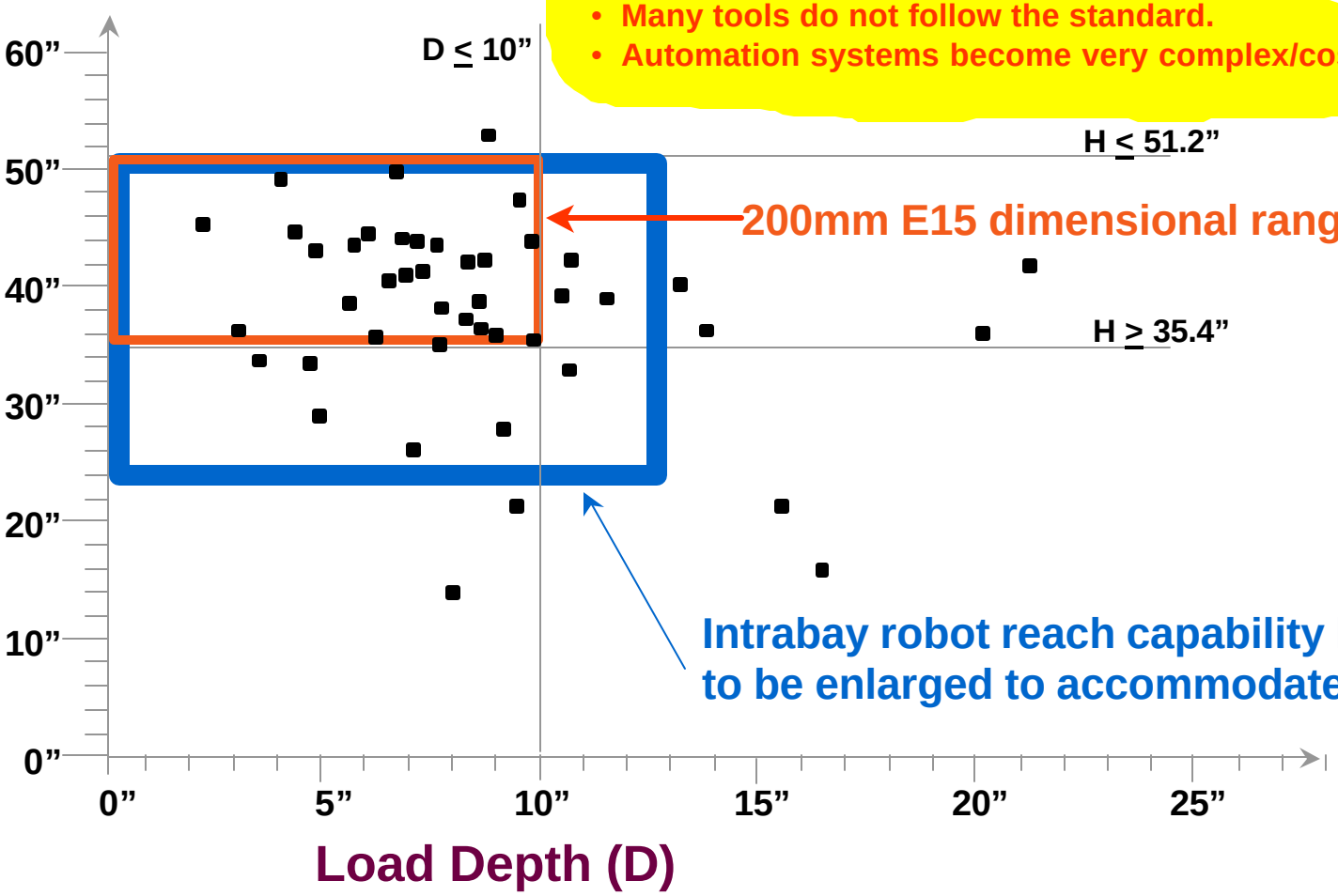
200mm E15 load port Evaluation: Adherence to H and D dimensions

STS97

Summary:
- Many tools do not follow the standard.
- Automation systems become very complex/costly.



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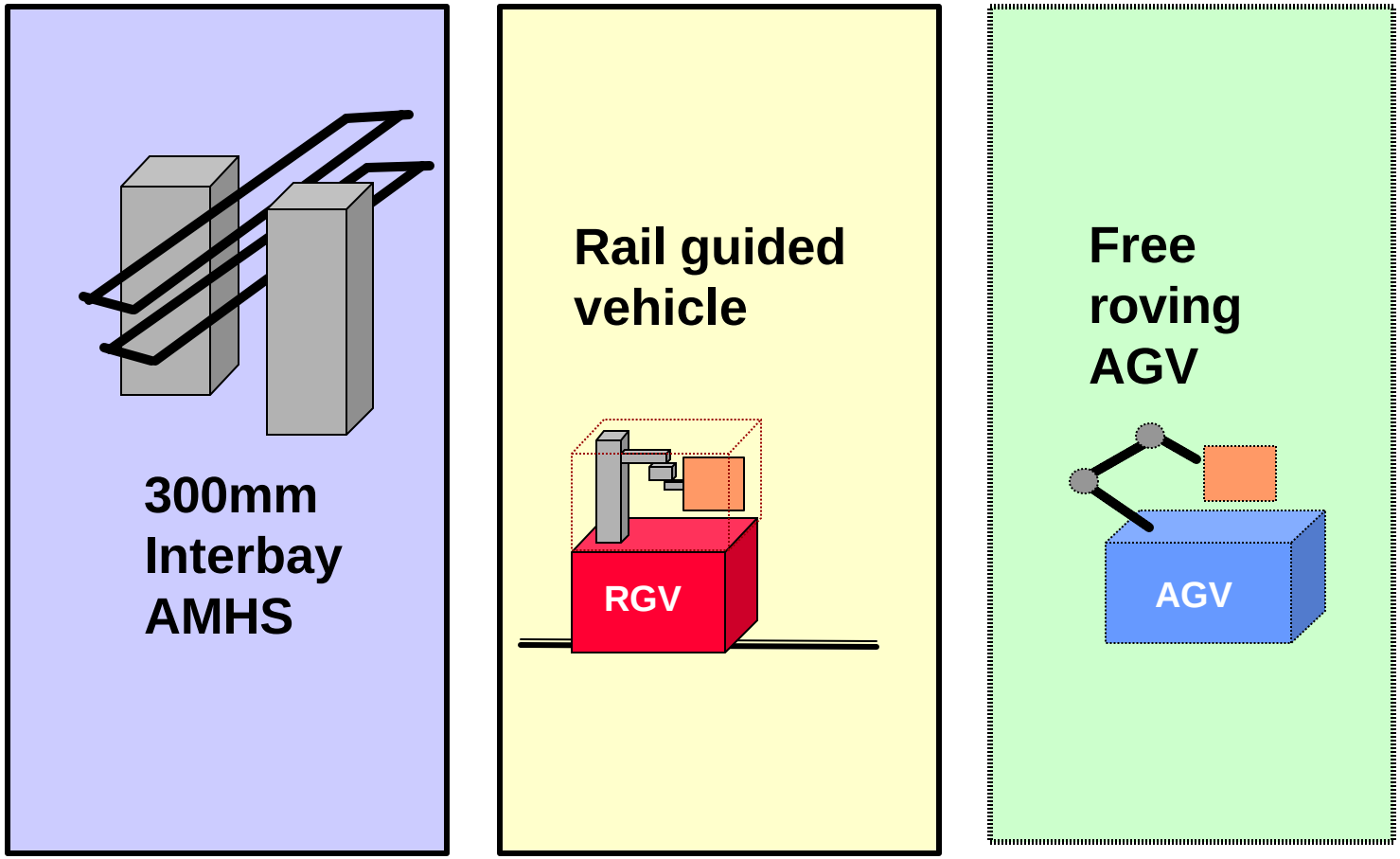
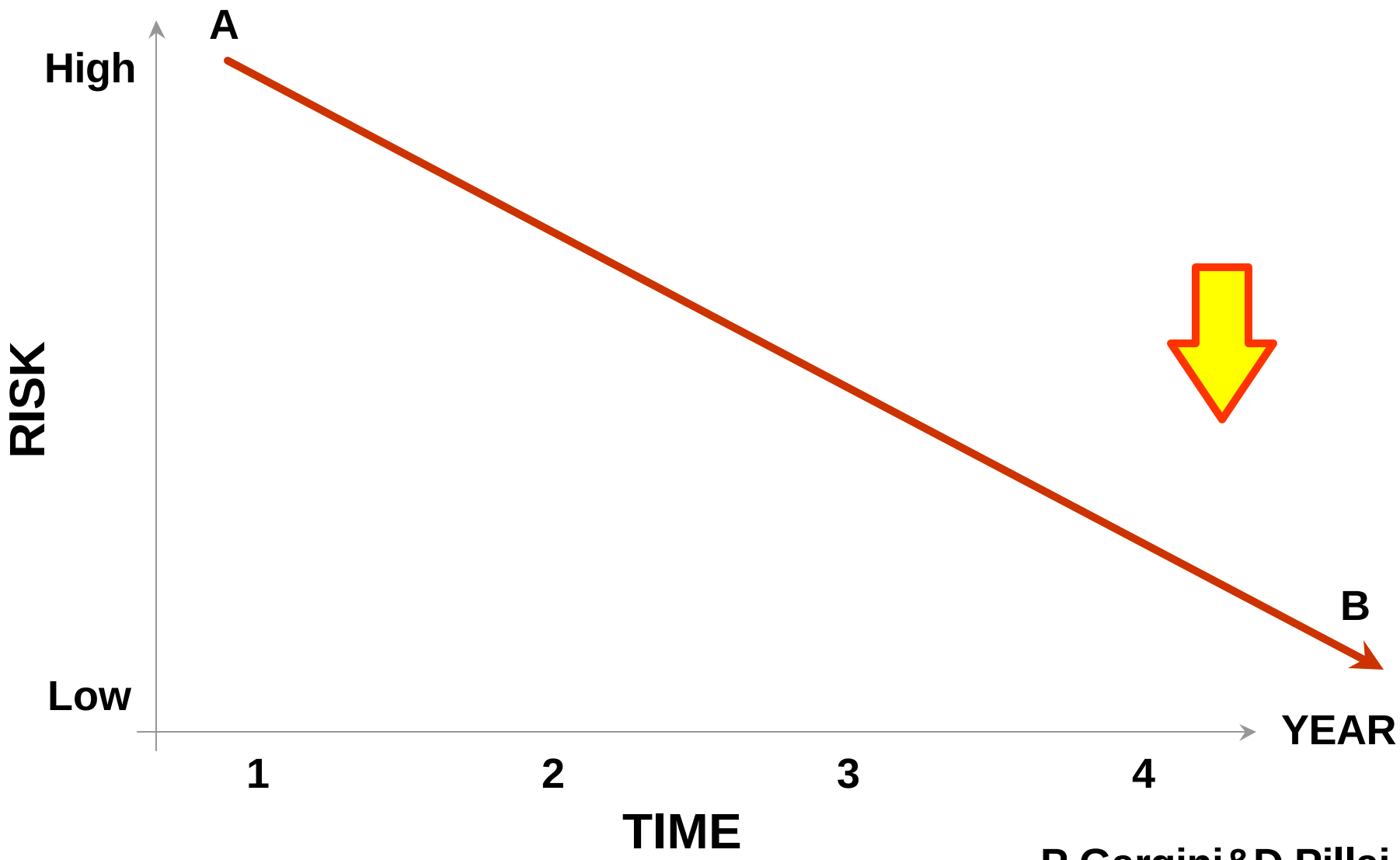
200mm AMHS Building Blocks



Consequences of lack of standardization

- Each semiconductor company approached automation in a different way
  - Extensive load port customization
  - Unique material transport solutions
- Multiple equipment solutions pursued
  - Increased equipment developement time
  - Increased equipment cost

200mm Standardization Process



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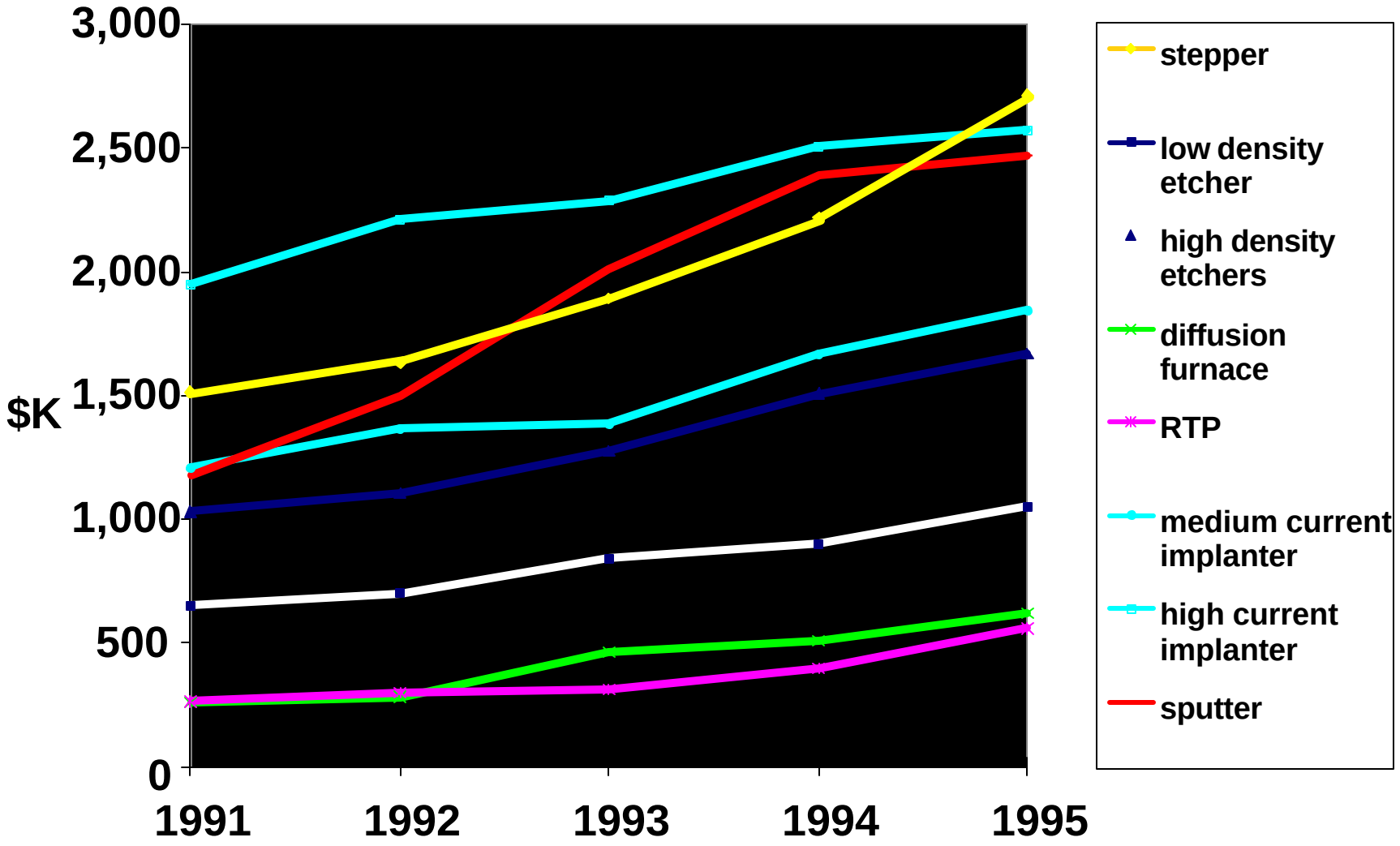
Equipment ASP Trends



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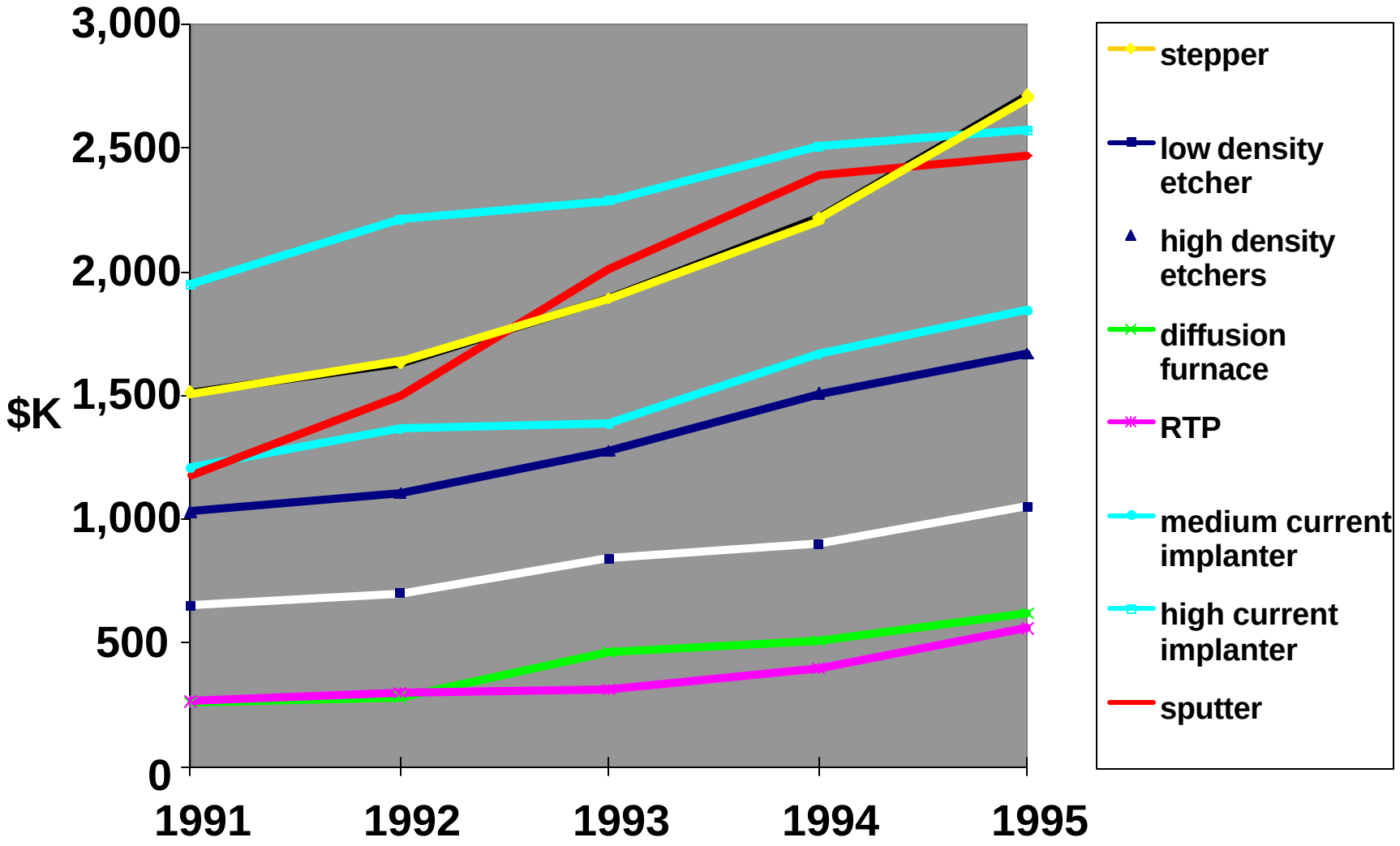
Equipment ASP Trends



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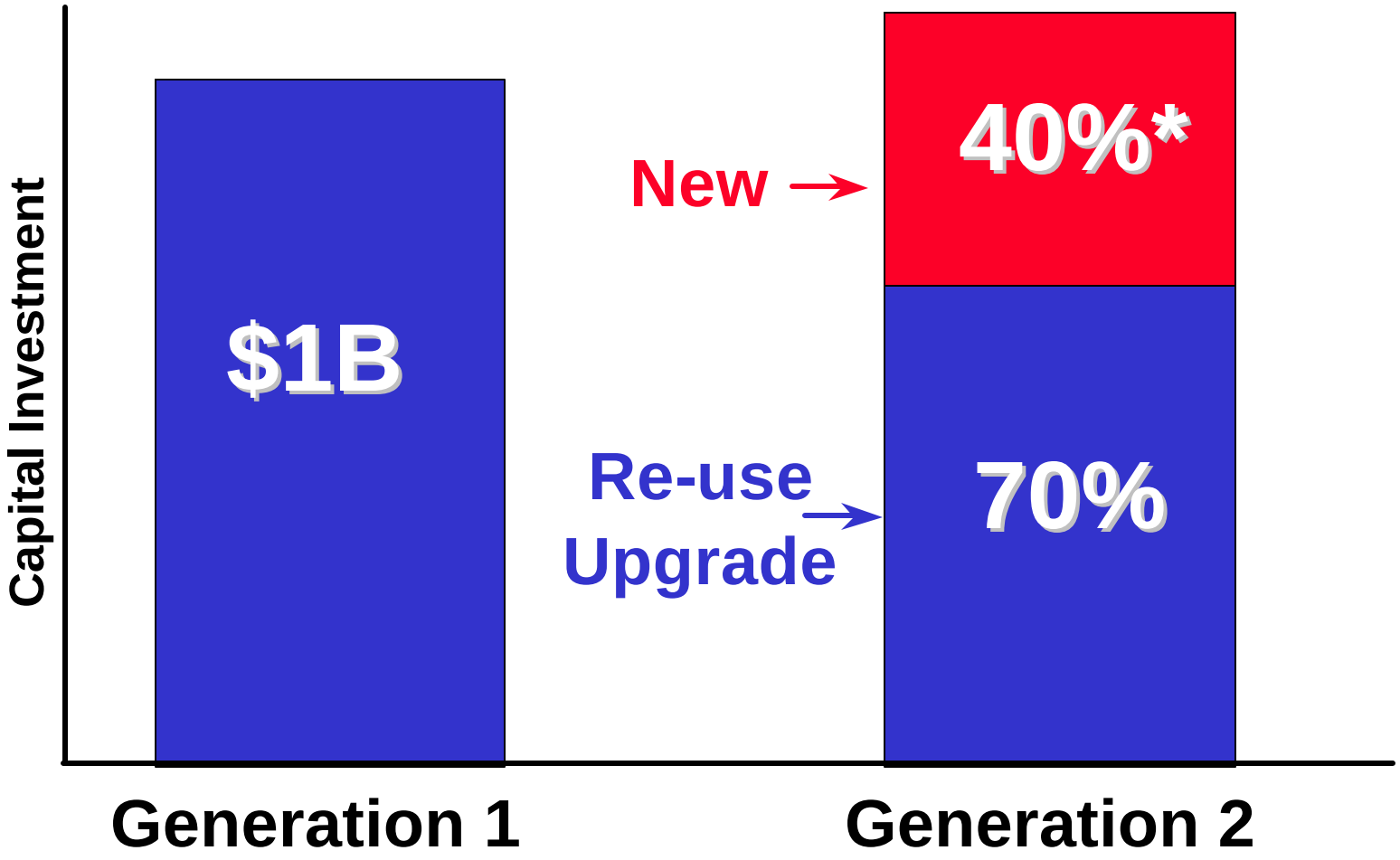
Capital Equipment Investment for New vs. Re-use of Installed-base



*10% higher complexity

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The 300mm wafer transition

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Wafer Size History

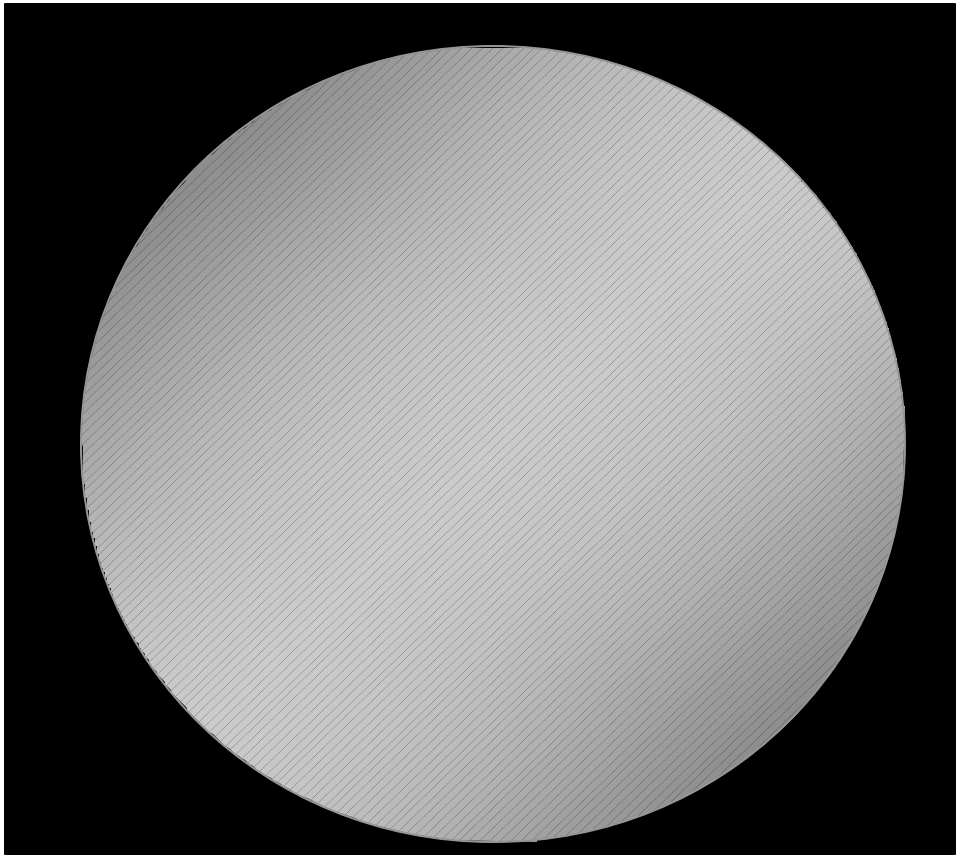
0.5”

1957

2”

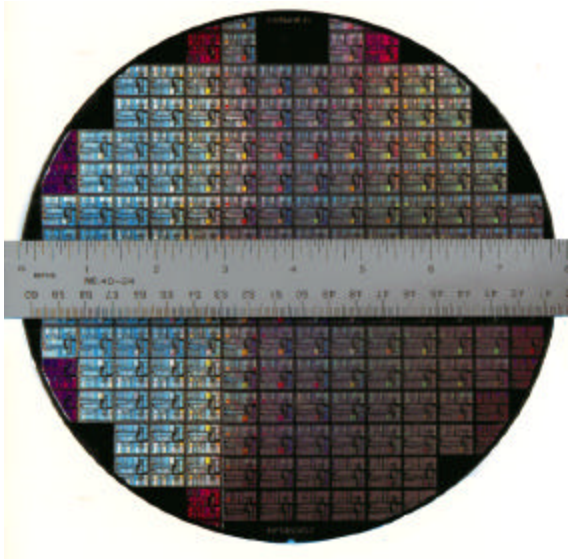
1971

12”



Tomorrow

8”



Today

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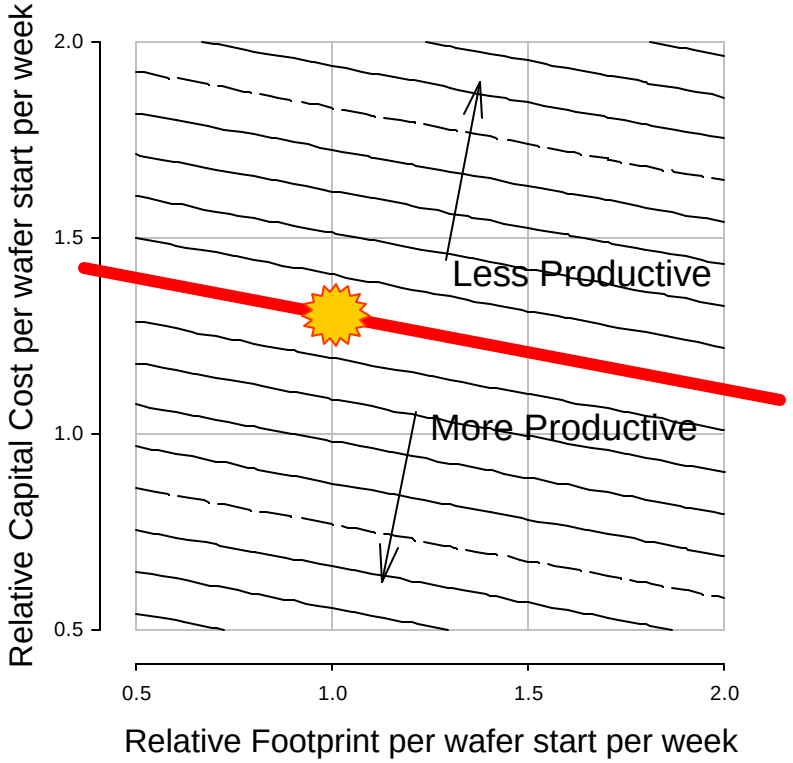
300mm Must Be More Productive than 200mm

- **Productivity can be measured by cost/die, people per wafer, factory size/wafer, ...**
- **A productivity analysis comparing 300mm to 200mm shows that the two parameters which most influence productivity are:**
  - ☞ Relative Tool Cost per wspw
  - ☞ Relative Tool Size per wspw
- **For every tool, these two parameters define a point on the graph.**
- **To meet the productivity targets, each such point must lie below the red line.**
- **This analysis drives 300mm planning in general, and Equipment Performance Requirements in particular.**

Defining 300mm Productivity



D.Seligson

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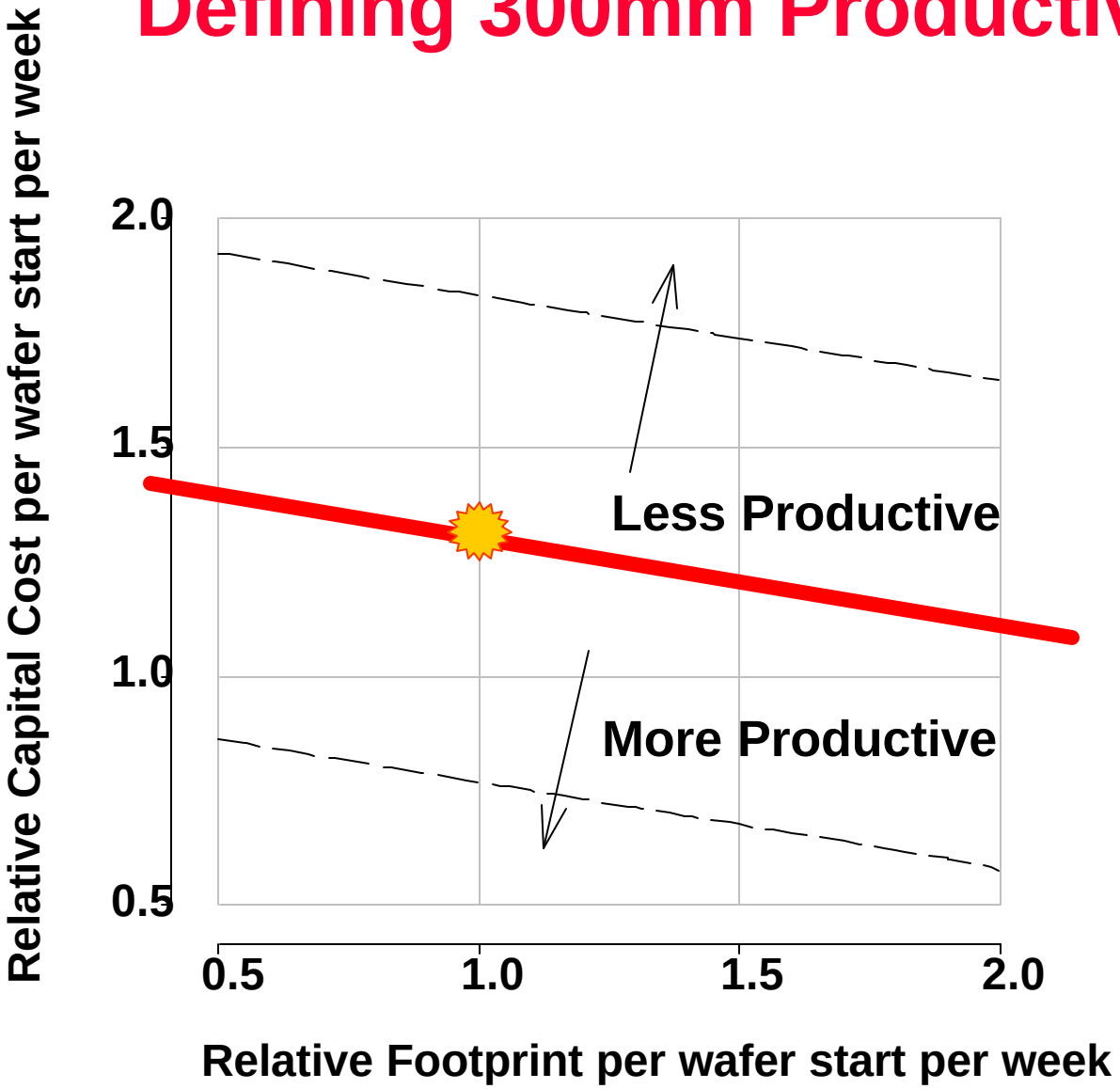
Defining 300mm Productivity



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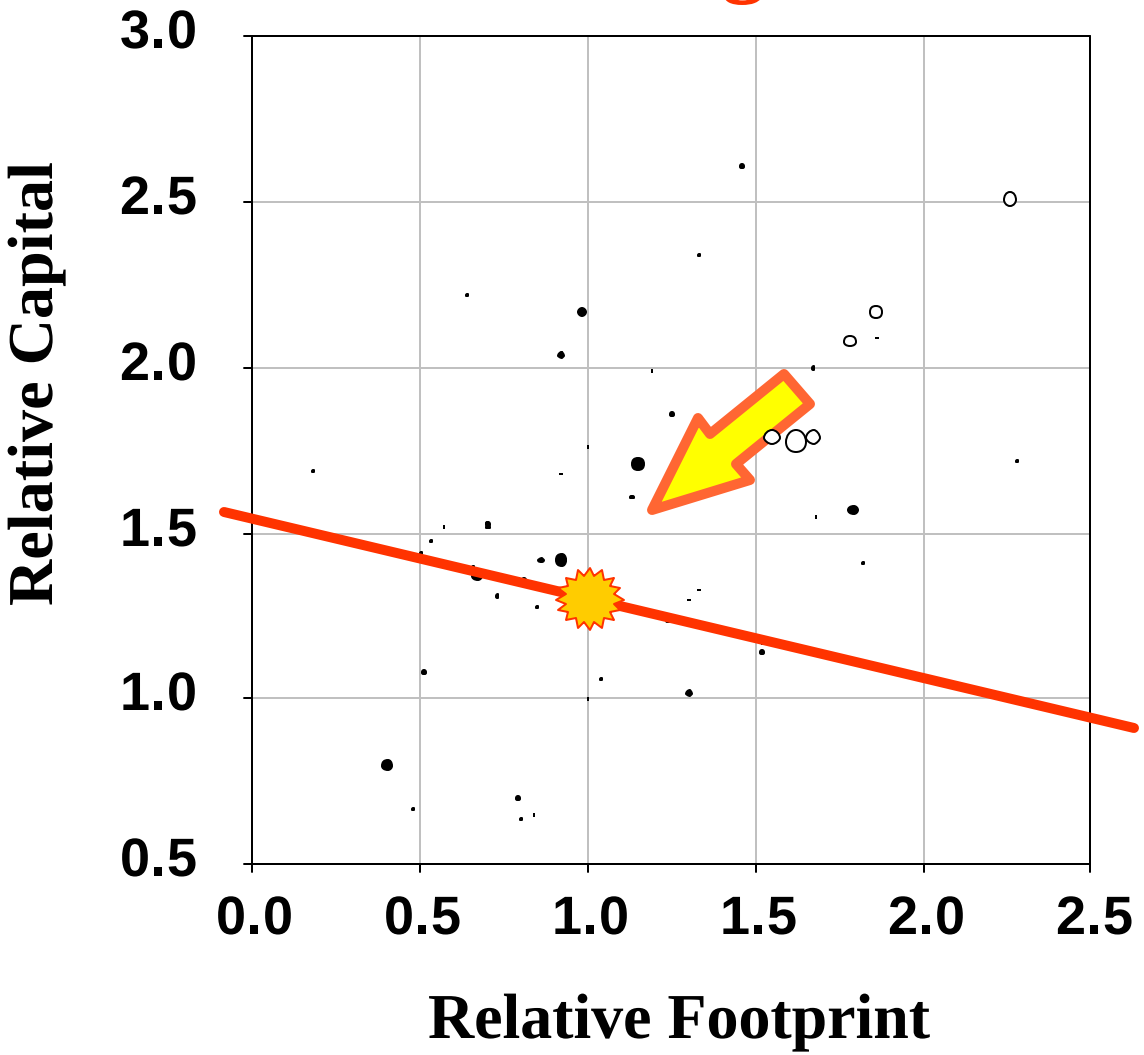
Early Productivity Scaling Factors for Tools in a 180 nm Logic Process Flow



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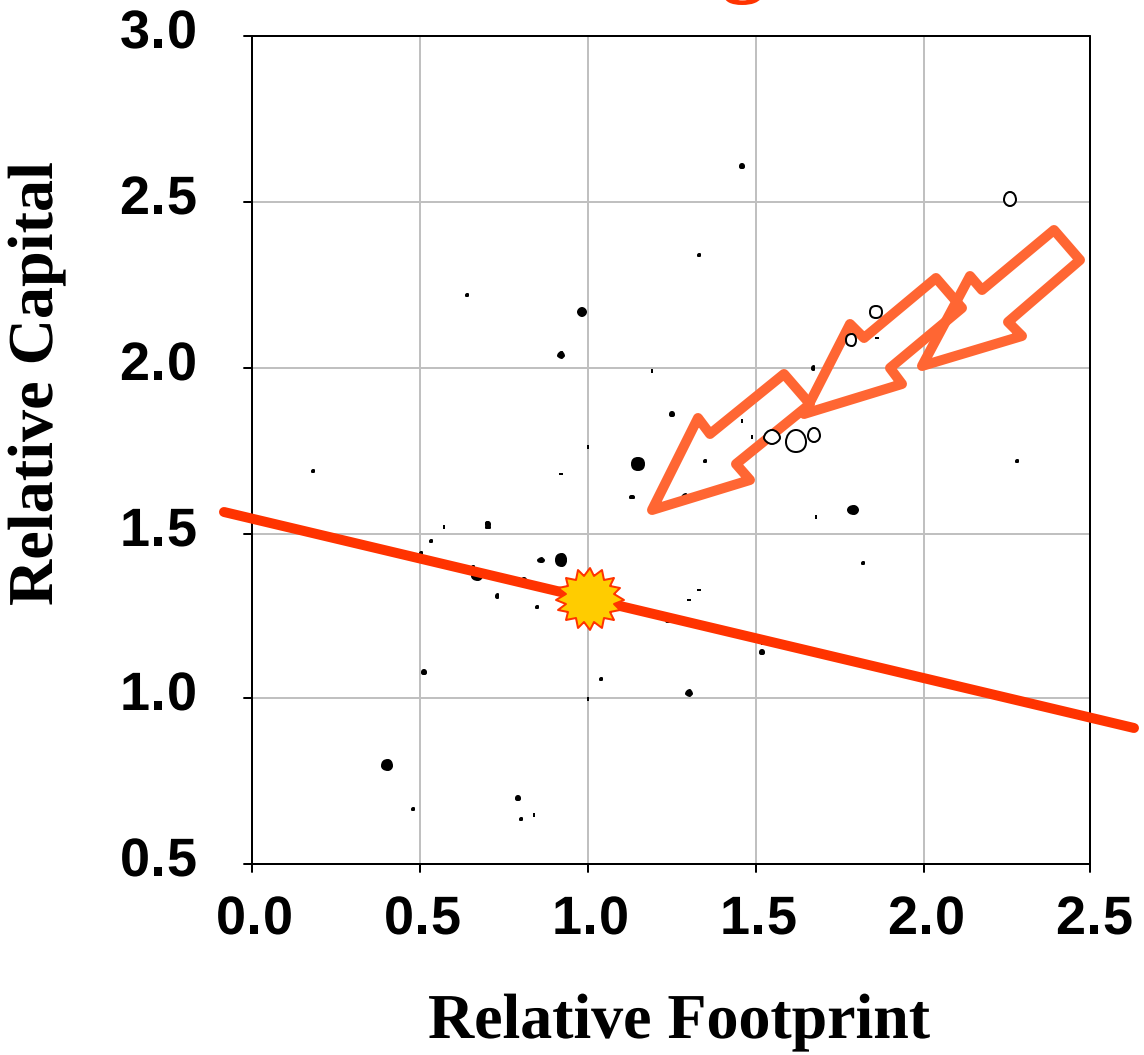
Early Productivity Scaling Factors for Tools in a 180 nm Logic Process Flow



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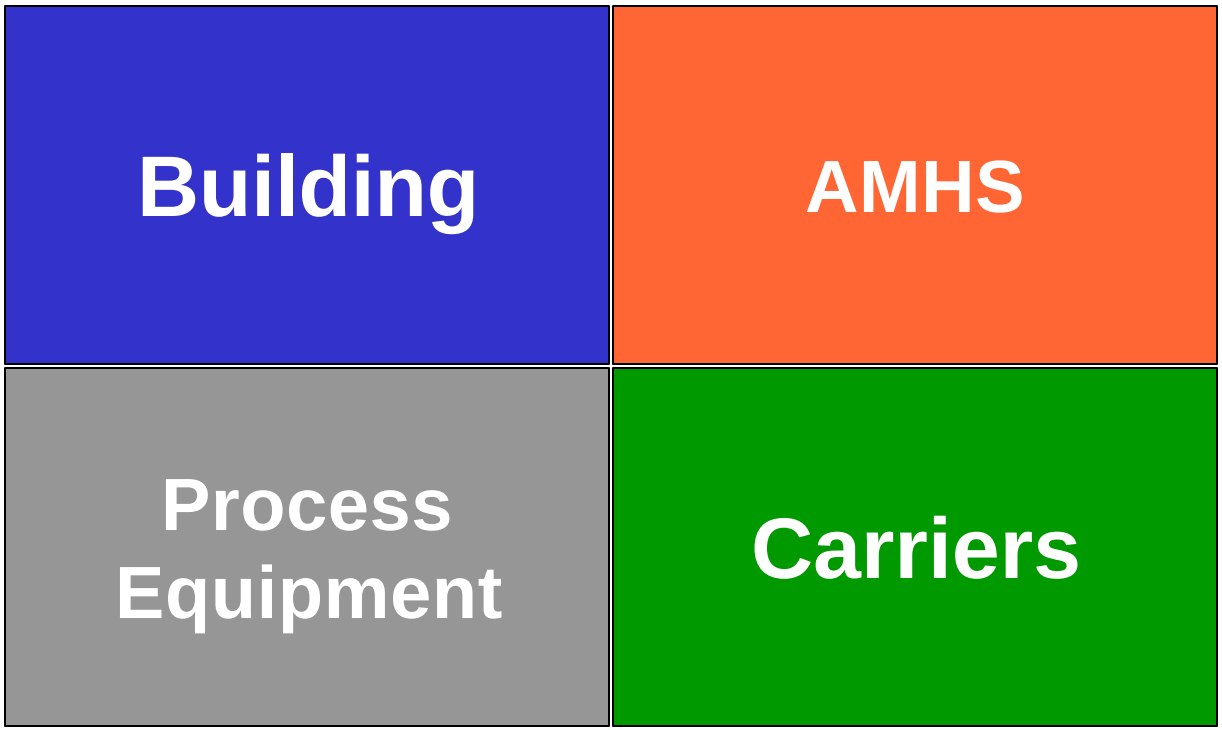
Conversion from 200mm to 300mm

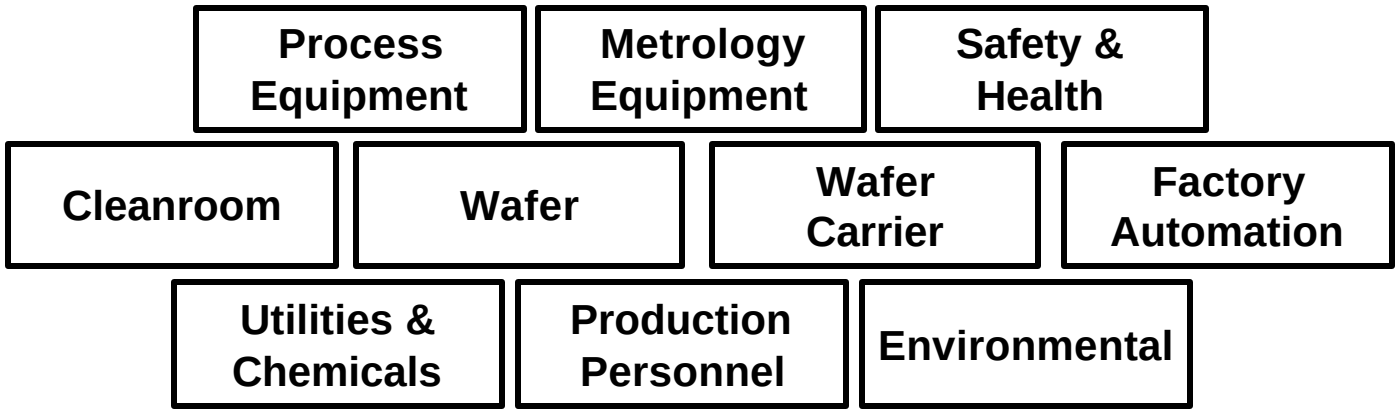
Synchronization= A renewed management challenge



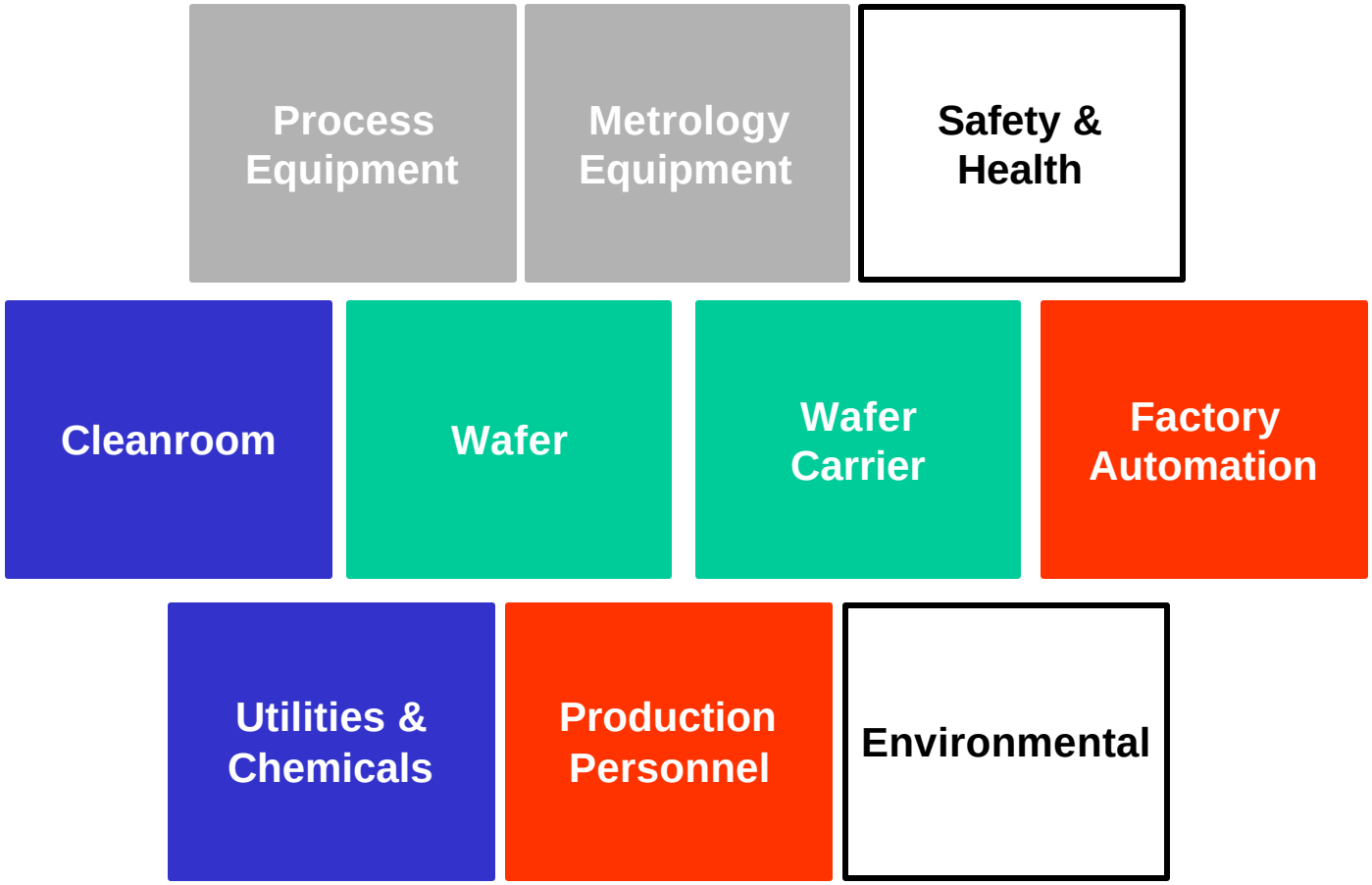
Why standards are important

- **Standards provide a mechanism for integrating the different elements of a factory cost-effectively:**
  - **Faster, better and cheaper**
- **Standardization provides opportunities for all:**
  - **If there is a standard, and you have a product that meets that standard, then you have an opportunity to compete in that business**
- **There are significant opportunities for 300 mm:**
  - Many factory elements are not well integrated for 200 mm
  - Significant cost reduction opportunities exist

Standards integrate important factory elements



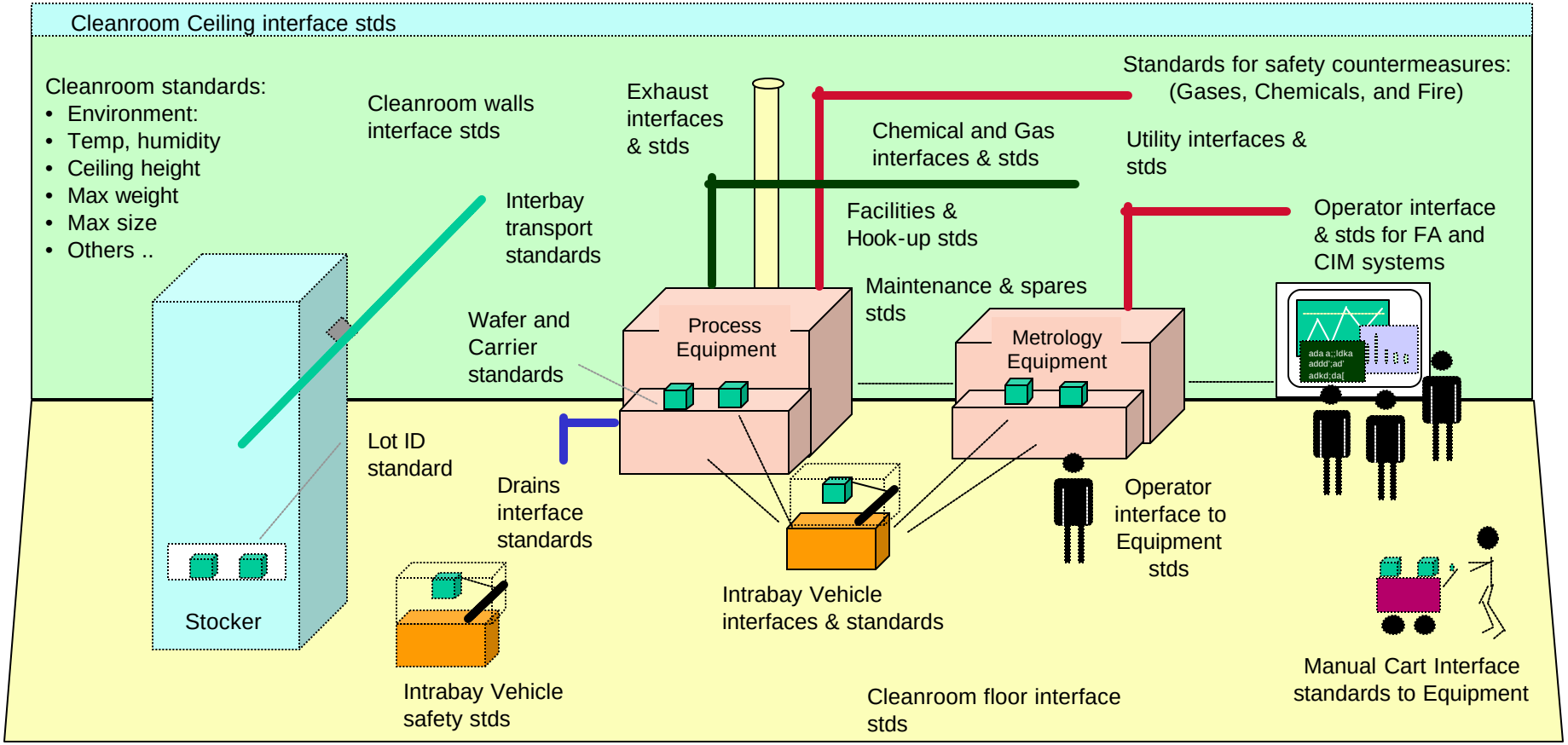
Standards integrate important factory elements



How standards benefit manufacturing

- Factory elements are better integrated and more consistent
- Systems work together cohesively and efficiently

Material supply container stds



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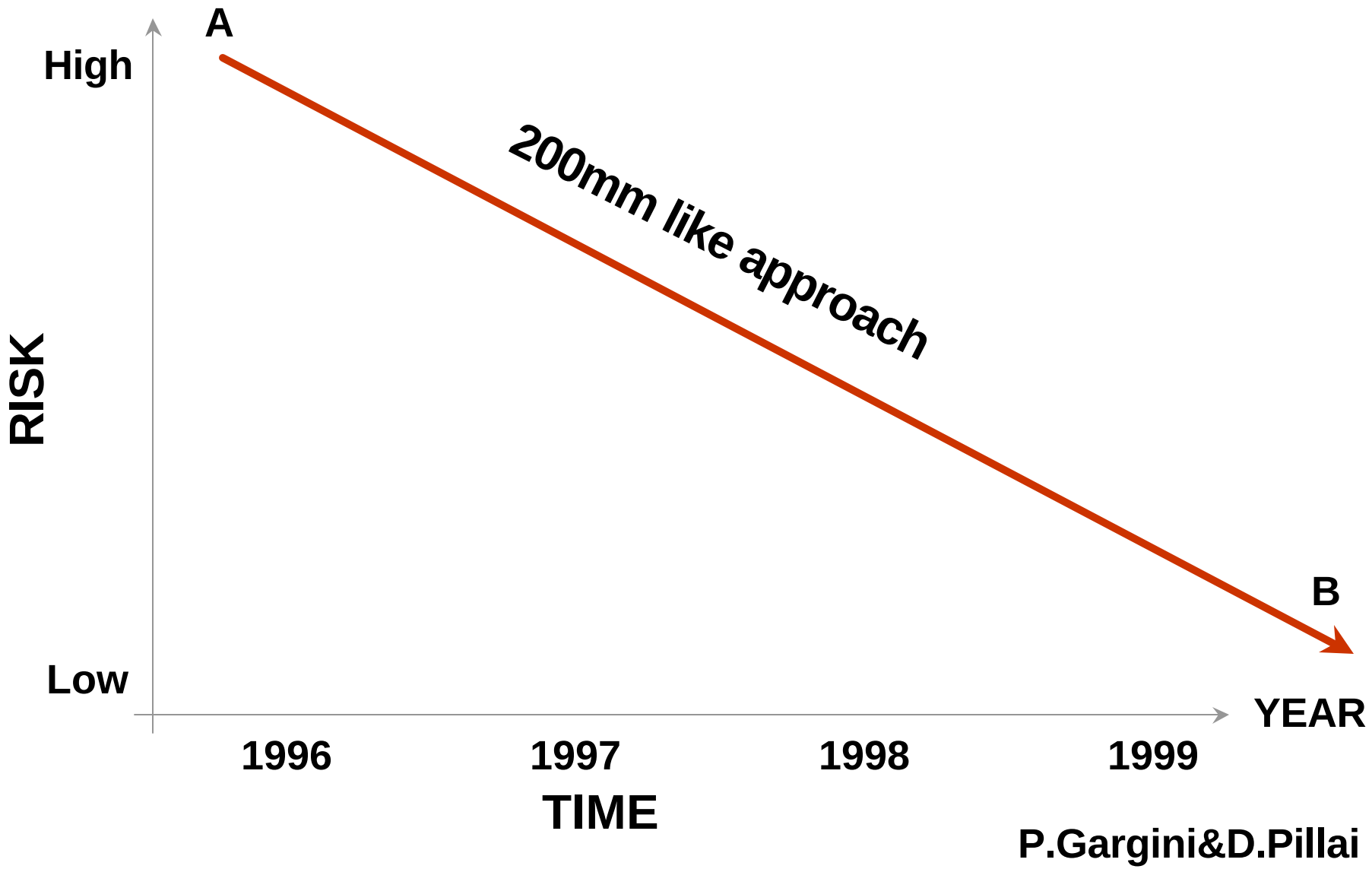
Traditional Standardization Process



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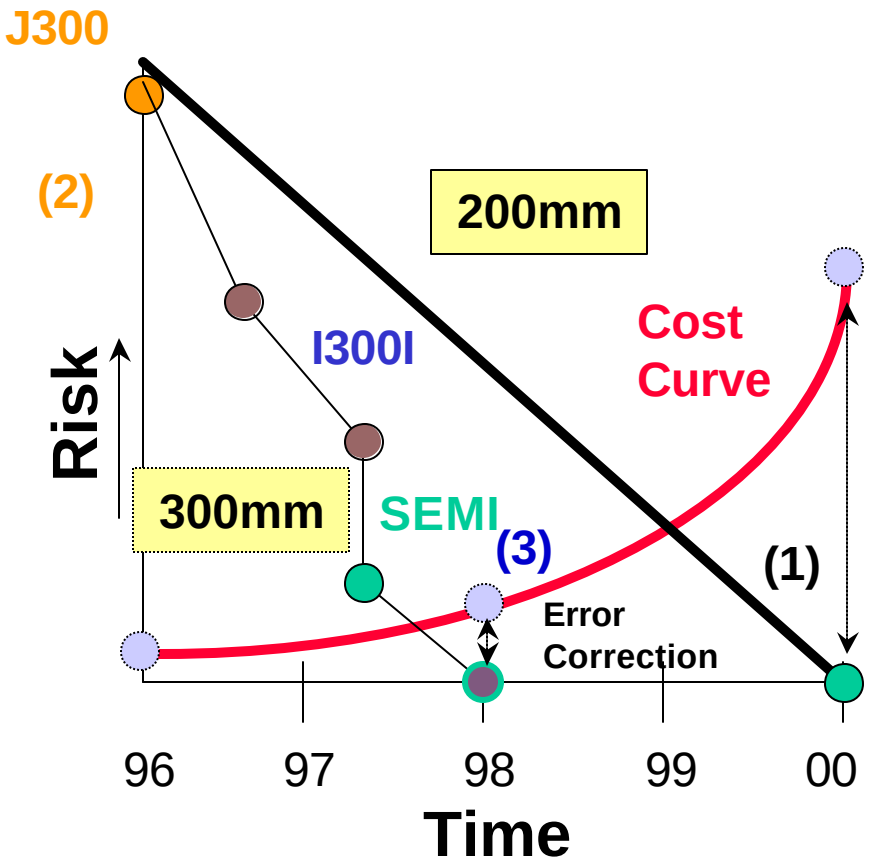
Standards Strategy for Semiconductor Industry



(1) Implementing Standards after technology development is low risk but high cost

(2) Implementing Standards alone before technology development is high risk but low cost

(3) By leveraging J300, I300I, and SEMI, we can achieve low risk and lower cost by combining our efforts and intelligence

- Doing standards together before volume manufacturing allows time for correcting issues that are found

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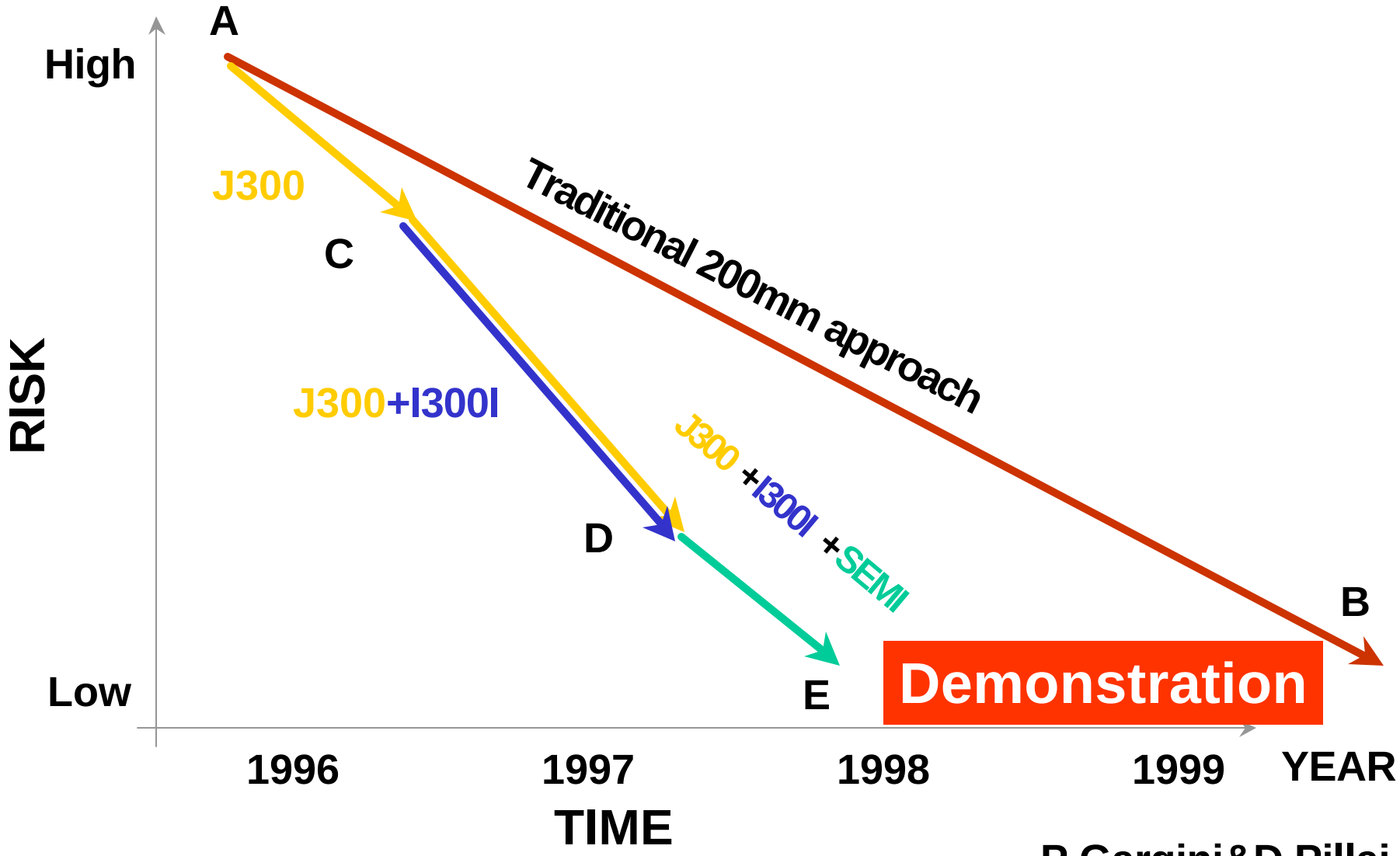
Risk Reduction using Global Participation and Standardization



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Factory Architecture

CIM SYSTEMS

HIERARCHY	MOVEMENT	COMPUTER	METROLOGY
FAB	→	HOST/SFC	X
JOB	→	JOB CONTROL	X
BAY	→	BAY CONTROL	X
EQUIP	→	EQUIP CONTROL	X
WAFER	→	WAFER CONTROL	X

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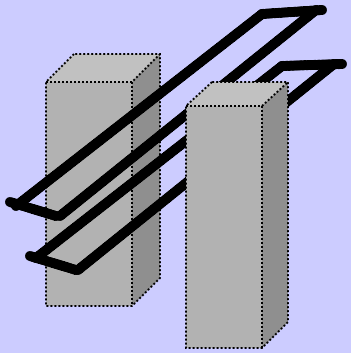
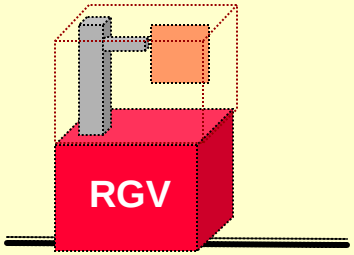
300mm AMHS Building Blocks

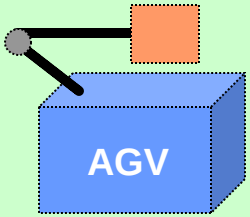


300mm
Interbay
AMHS

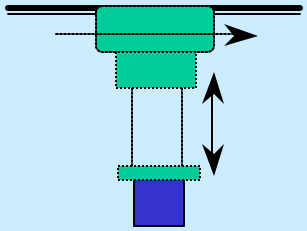
Rail guided
vehicle
RGV



Free
roving
AGV



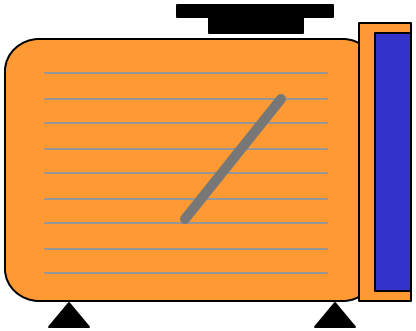
Overhead
hoist
vehicle



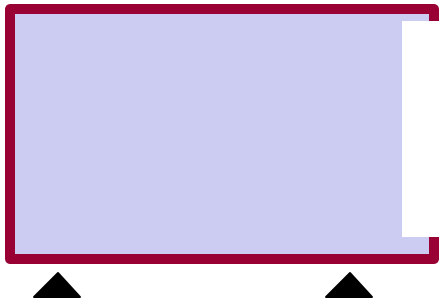
OHV

FOUP and Open Cassette

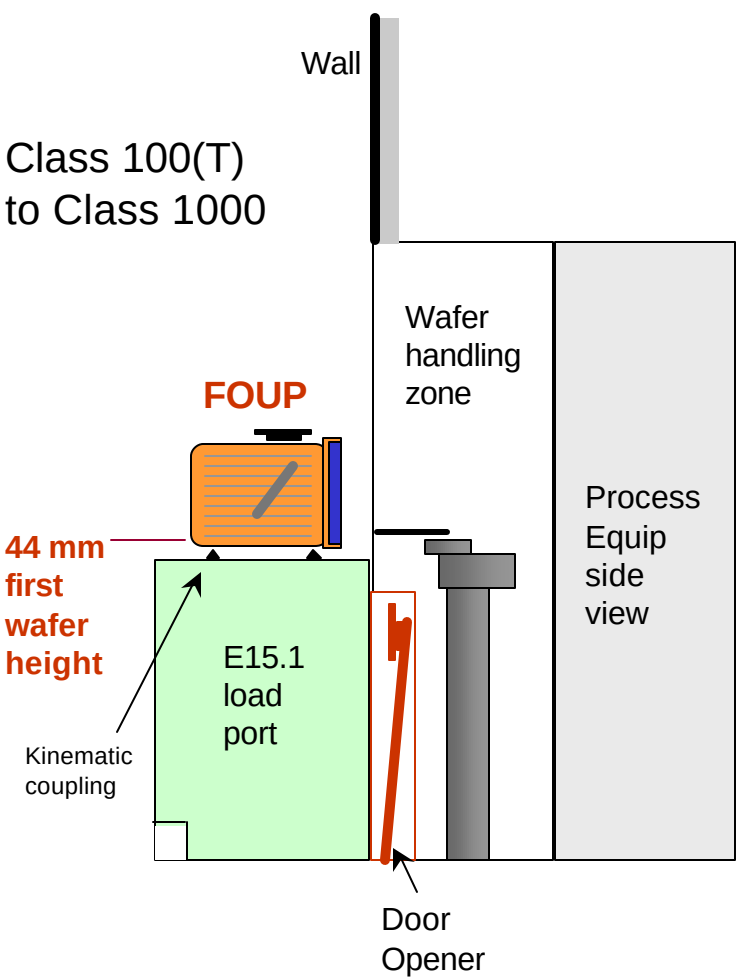
FOUP

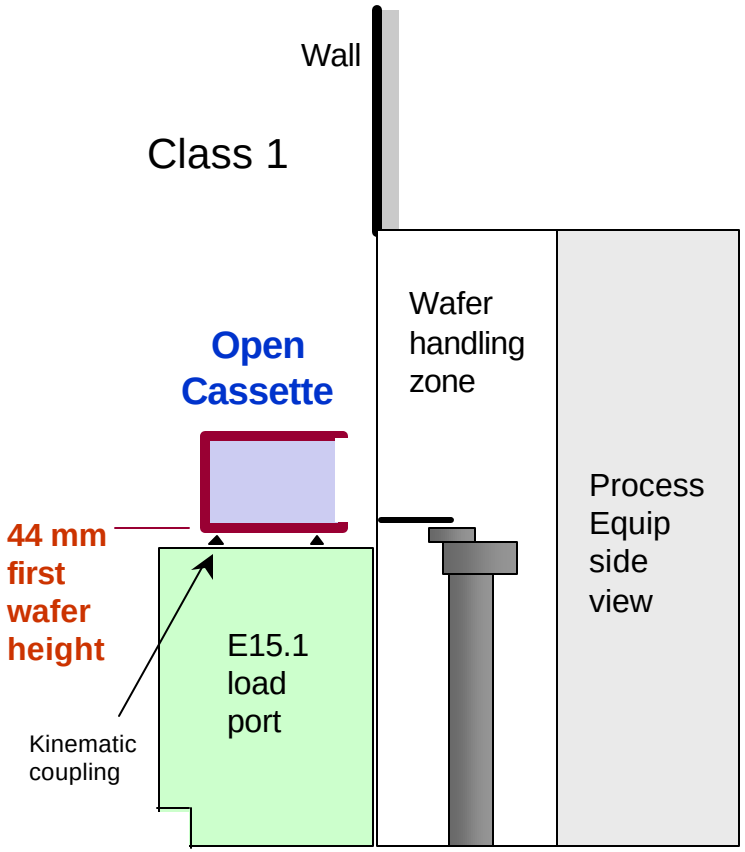


Open Cassette



FOUP and Open Cassette Compatibility





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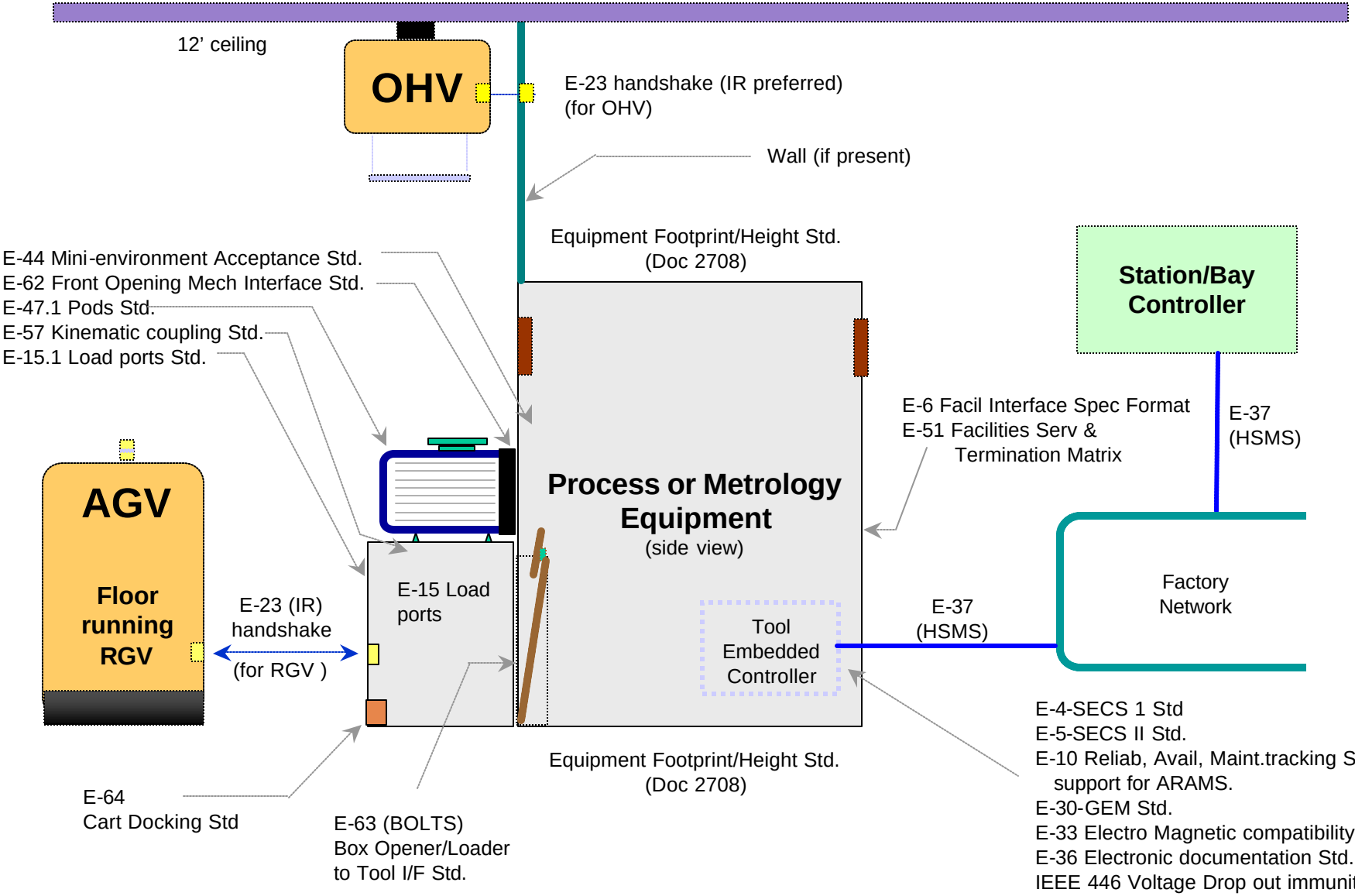
"MUST HAVE"
SEMI Standards covering Interfaces



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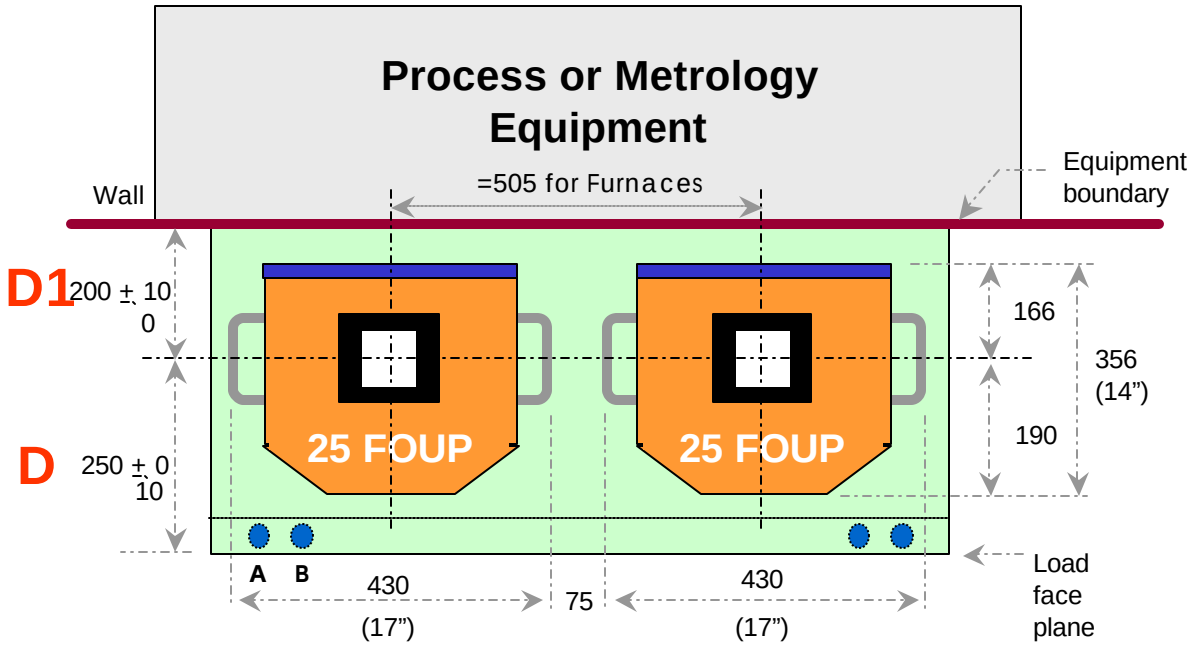
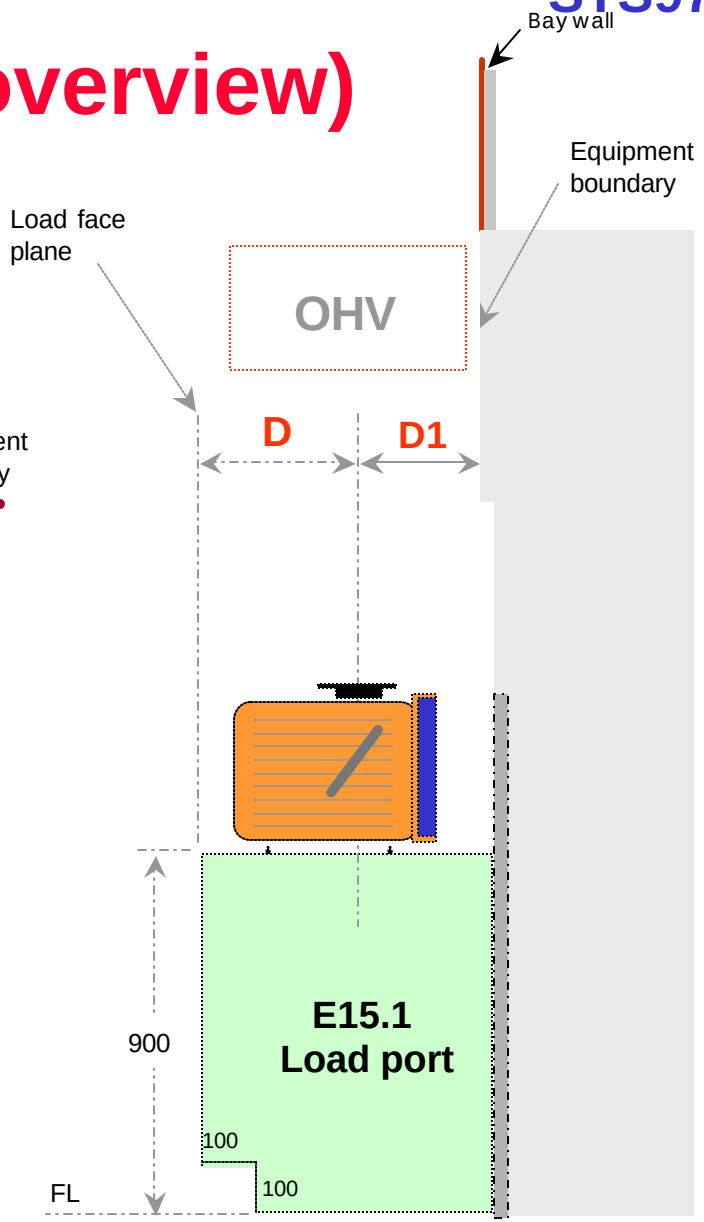
SEMI Standards (overview)



E-15. 1 Plan View



SEMI E-64 std
Cart Docking
Exclusion Zone

Side View

A. Carrier placement OK indicator
B. Carrier presence indicator

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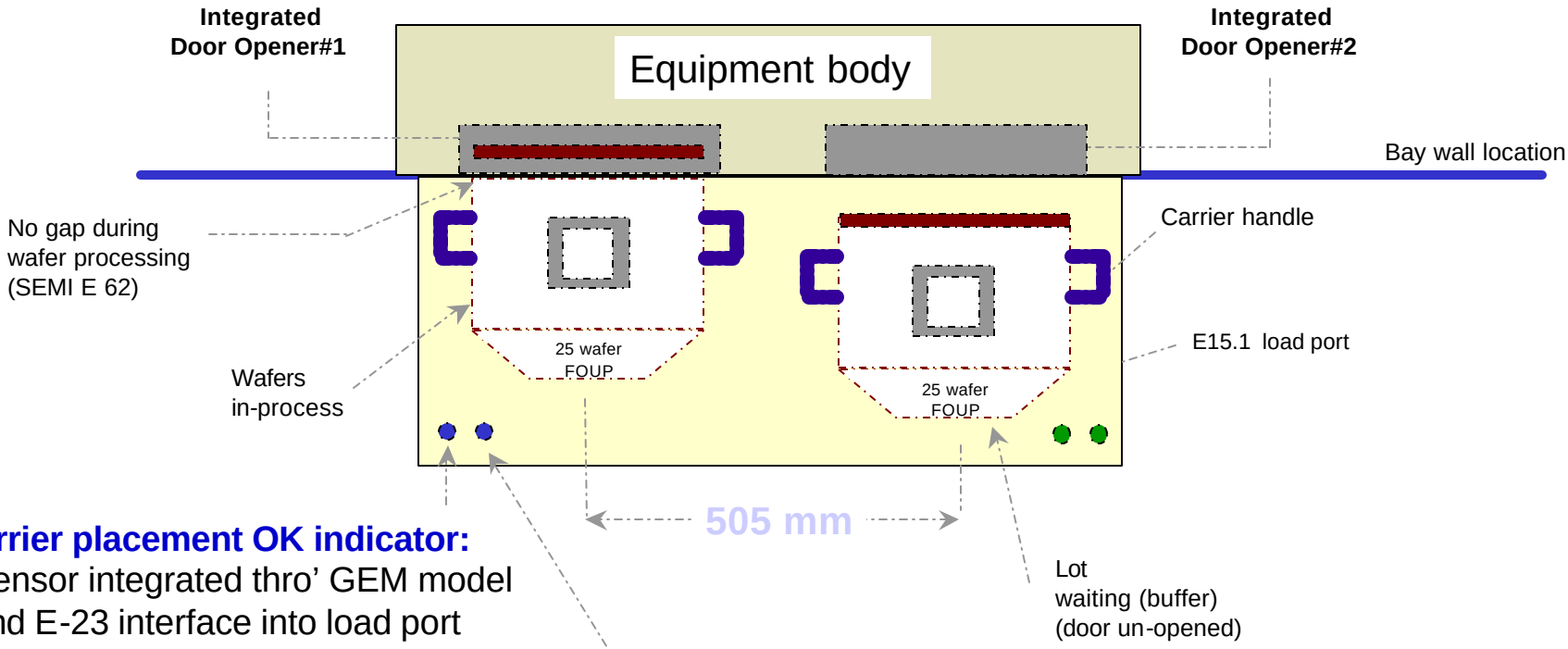
E15.1 load ports



Carrier placement OK indicator:
Sensor integrated thro' GEM model and E-23 interface into load port

Carrier presence OK indicator:
Sensor integrated thro' GEM model and E-23 interface into load port.

Tools such as the Furnace, Implanter, Wet Station, and Litho Track need more that 1+1.

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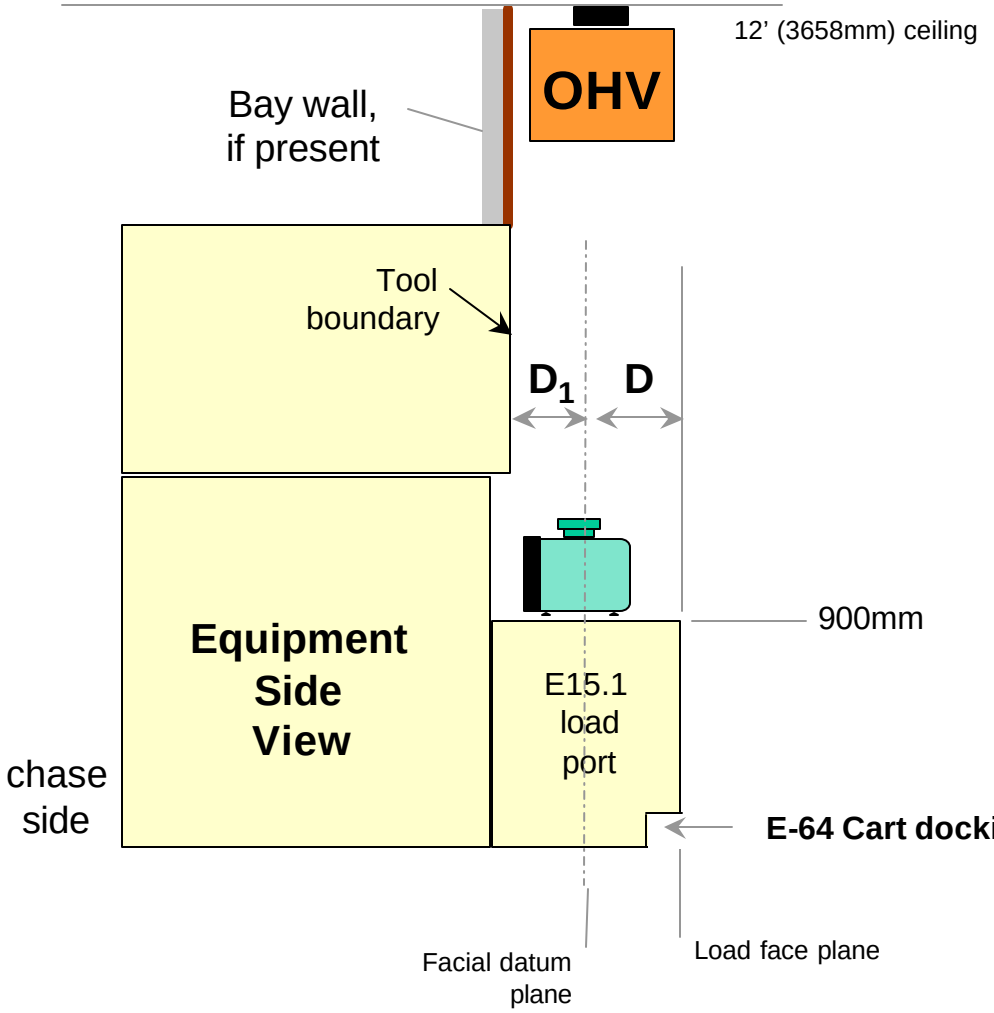
Dimensions D and D_1 in SEMI E15.1 are critical for OHV and RGV implementation



SEMI E15.1 standard

$D = 250 \pm^{0}_{10}$ mm

$D_1 = 200 \pm^{10}_{0}$ mm

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Recently Passed Provisional Standards

- E15.1 - Loadport Standard
- E47 - Front Opening Unified Pod
- E57 - Kinematic Coupling
- E62 - Front Opening Interface Mech Standards
- E64 - Cart Docking Standard

These are I300I and J300 Endorsed SEMI Standards

Please use them in your equipment design!!!!!!

Intel's Synergy with 14 I300I Guidelines

(http://www.I300I.org)

Carrier Architecture:

- 25 wafer capacity carrier.
- SEMI stds compliant.
- Front Opening Unified pod.
- Pod handles for Operators & Automation.

Overhead Carrier Delivery:

- Easement for delivery system
- E15.1 Option 1 compatible

"Integrated" Mini-Environment:

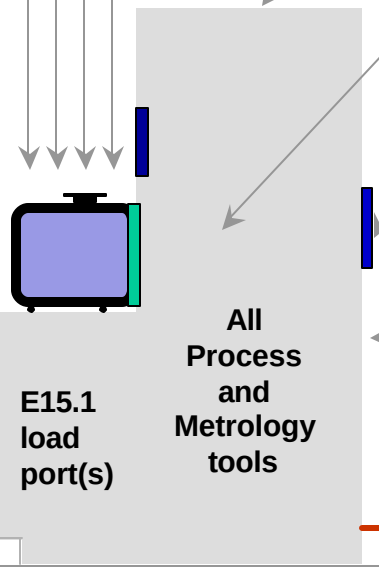
- reqd. on all Beta equipment.
- requires Door Openers integrated to all tools.
- Buffers to be ME compatible.

Non-stop wafer processing:

- Basic requirement is 1+1.
- Addtl. buffering is reqd for Furnace, Wet Stn, Implanter and Litho track.

Loadports:

- E15.1 with door openers.
- Slot/Cassette integrity.
- Ports only on one side.
- Straight line installation in bay, along bay wall.



U/I Controls/Display console

- Alternate connection to be provided.
- This is functionally equivalent to the one in the front.

Dense packing in bay:

- should be supported. without maintainability impacts.

Material Handling handshake:

- Low-level handshake.
- SEMI E23 interface (use IR option)

Cart Docking Interface:

- SEMI E-64.

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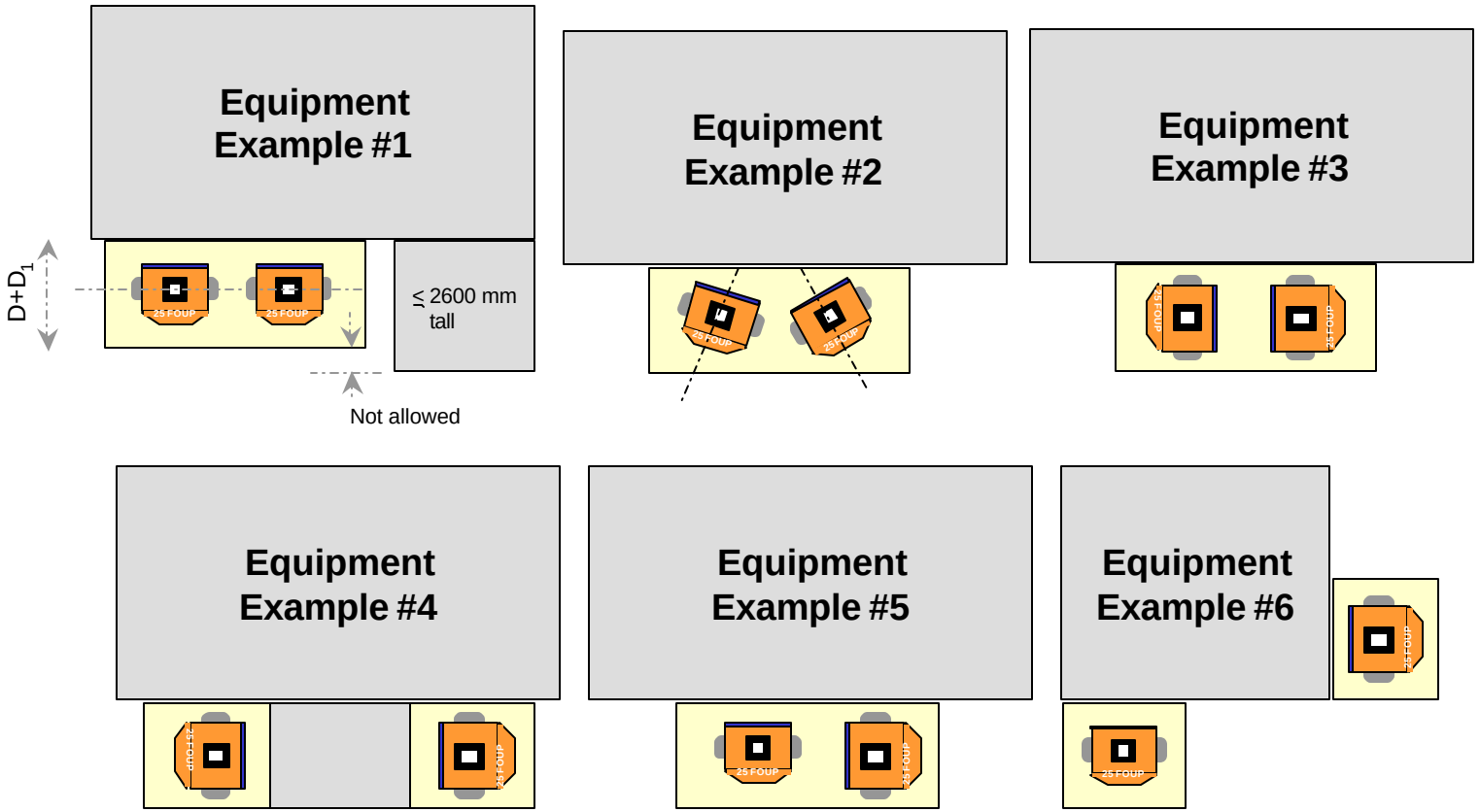
Some designs that don't meet Standards



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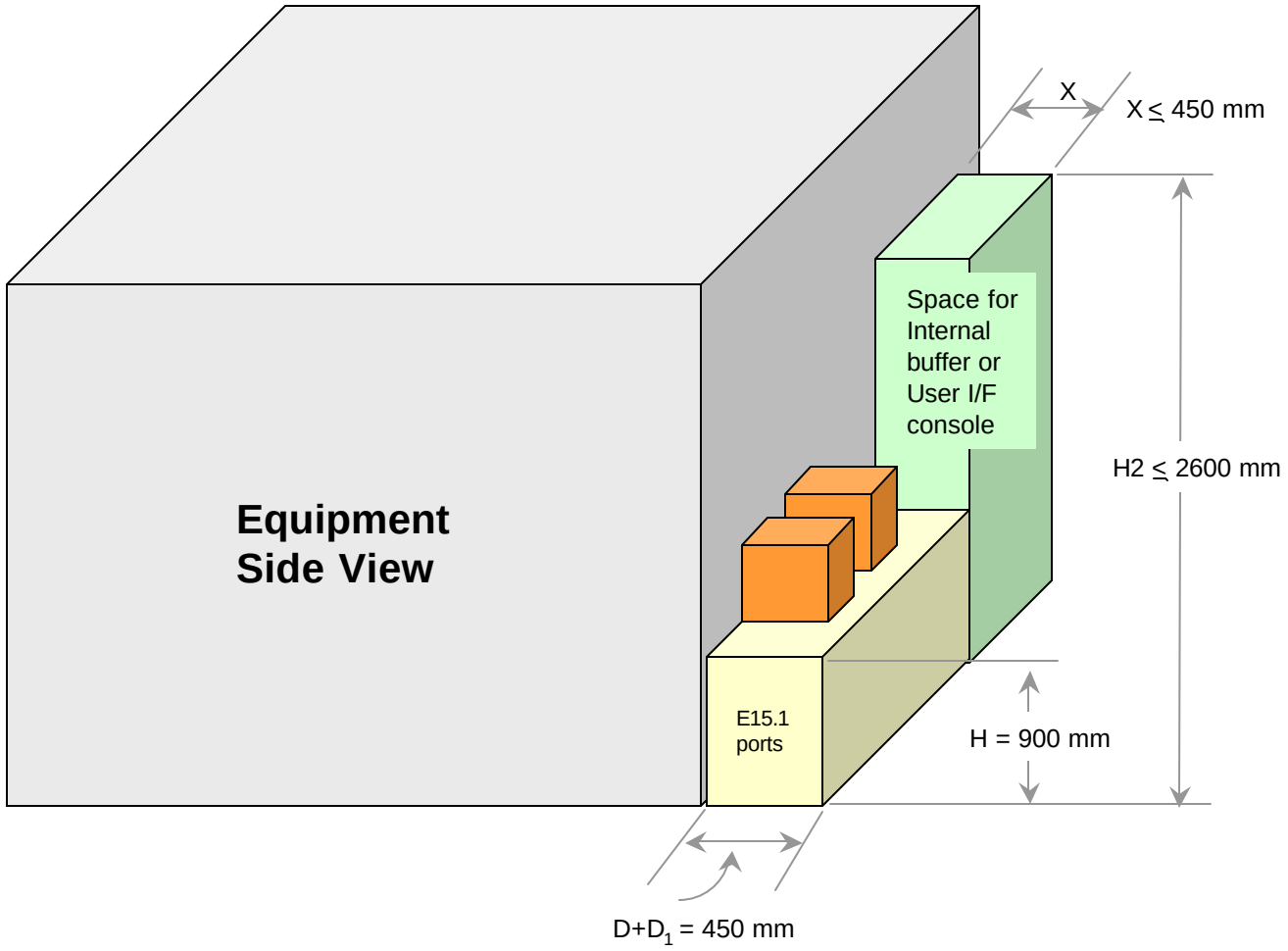
A Valid Equipment Configuration



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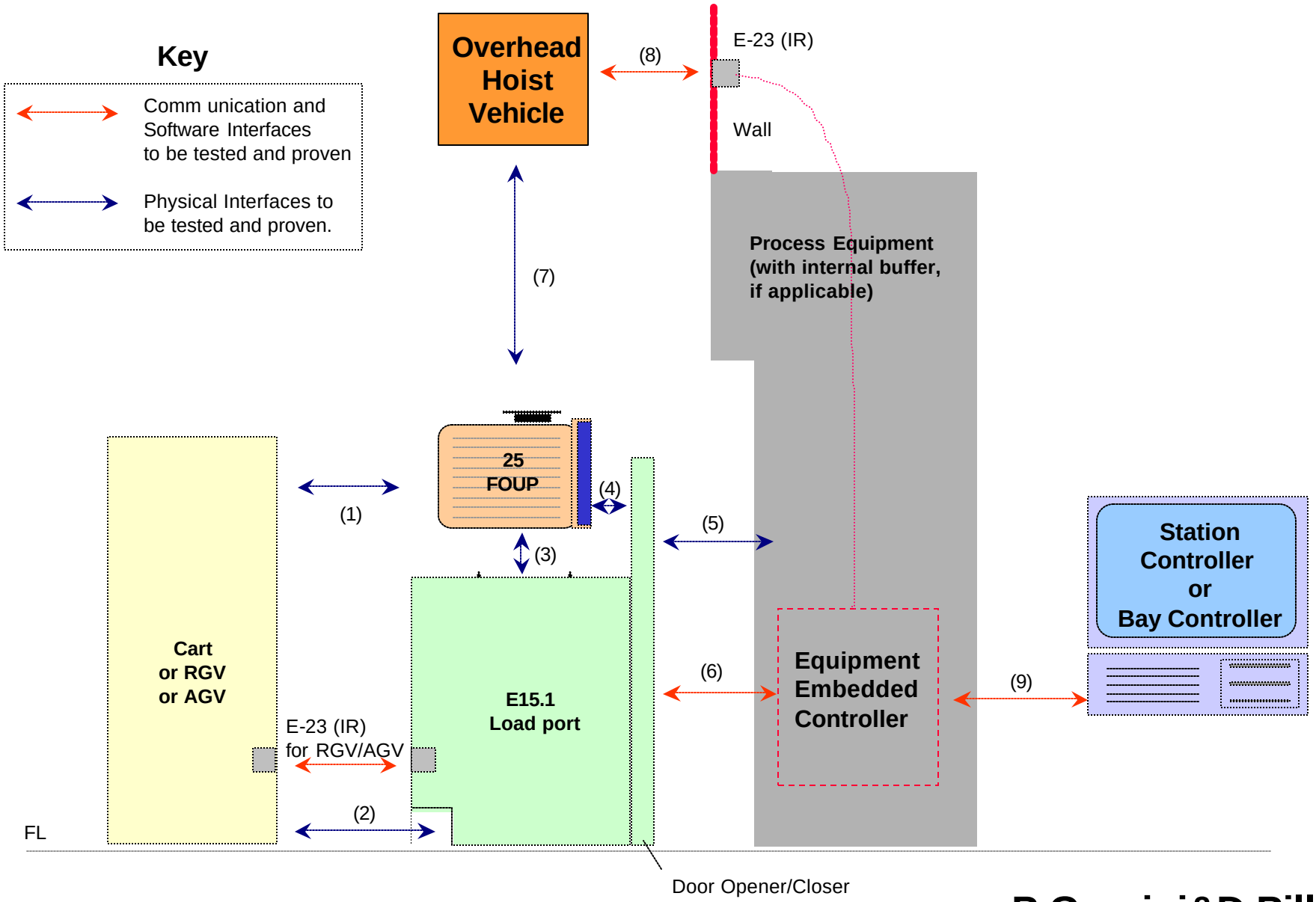
Inter-operability Interface testing



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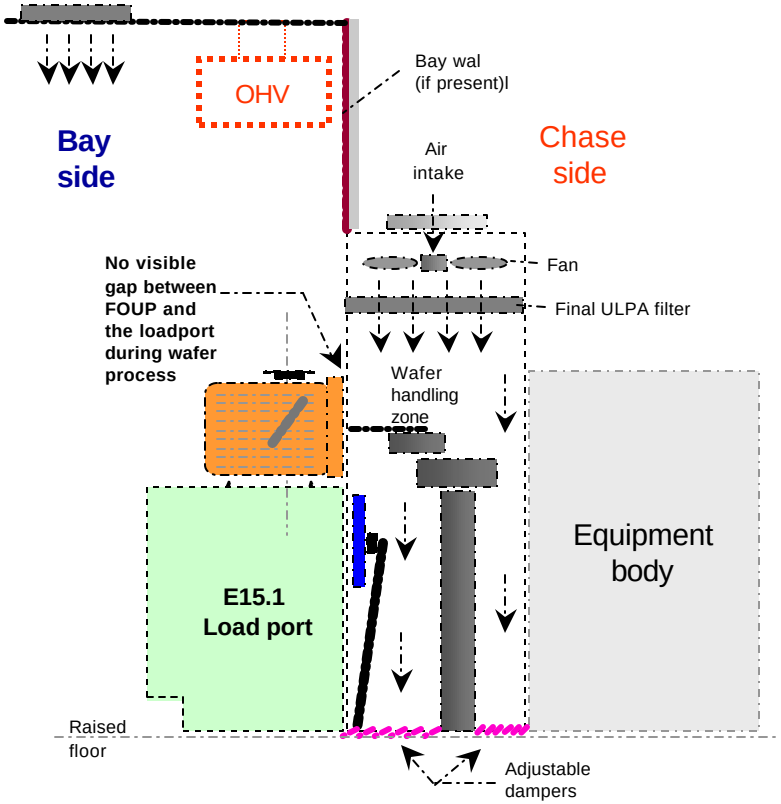
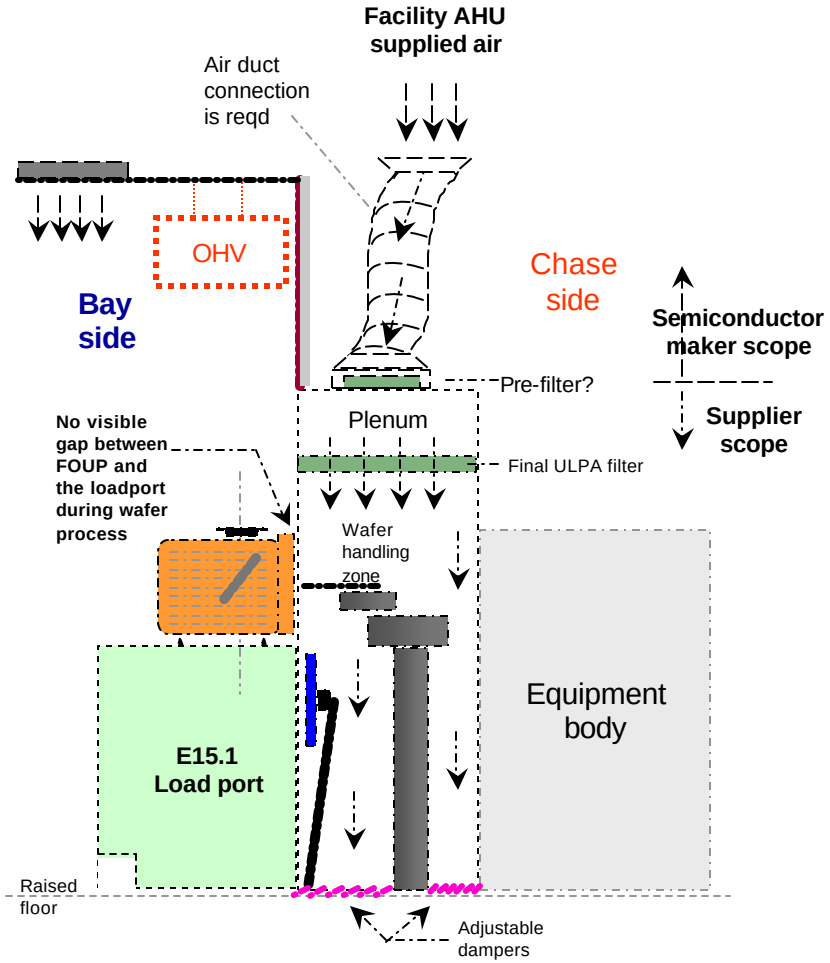
Integrated Mini-Environment is required

Integrated Mini-Environment



We want this!

Facility Supplied Mini-Environment



We don't want this!

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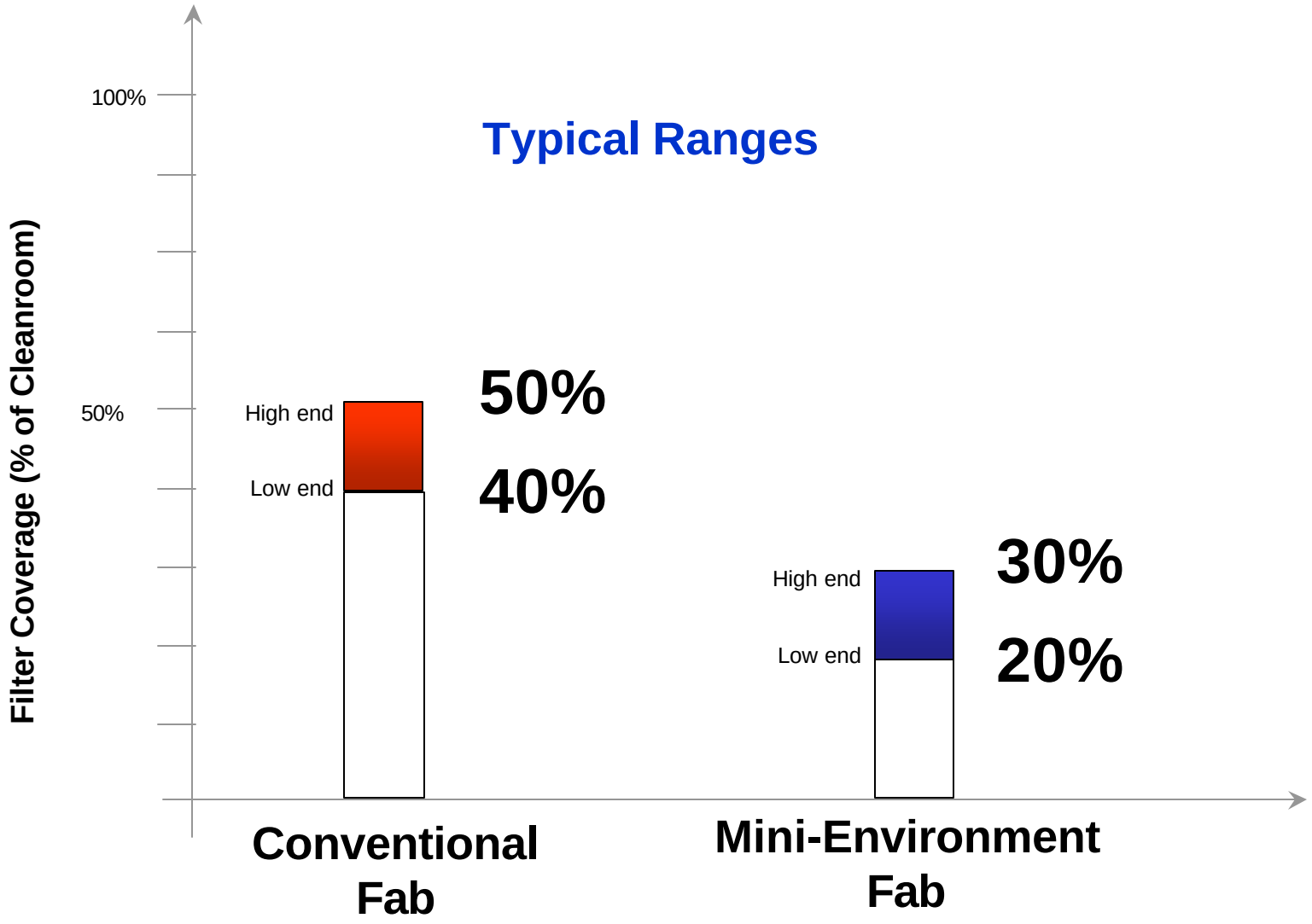
Reduced Filter Coverage with ME



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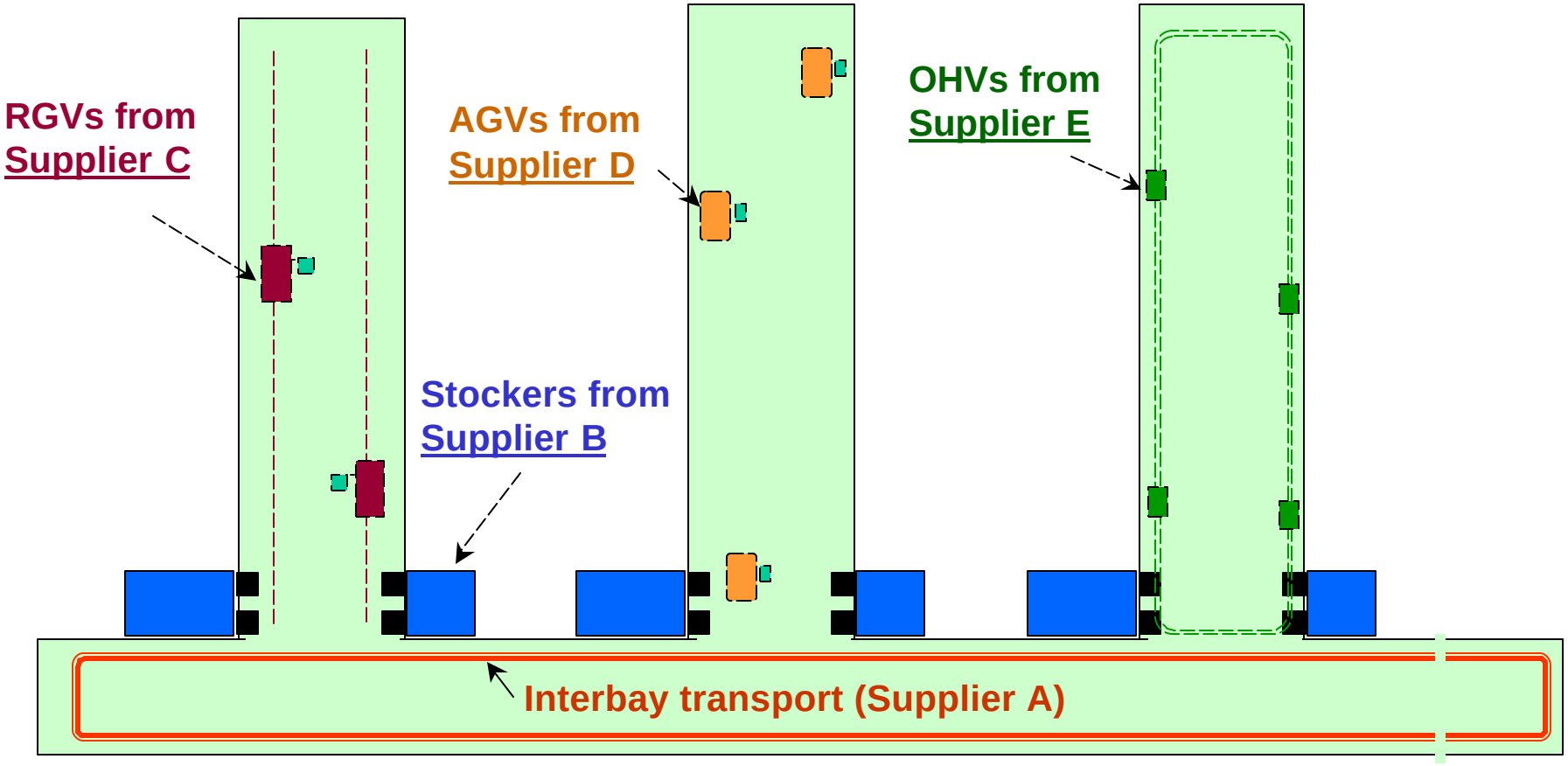
Standards enable AMHS to Inter-Operate



Use best systems that meets throughput, flexibility and cost goals

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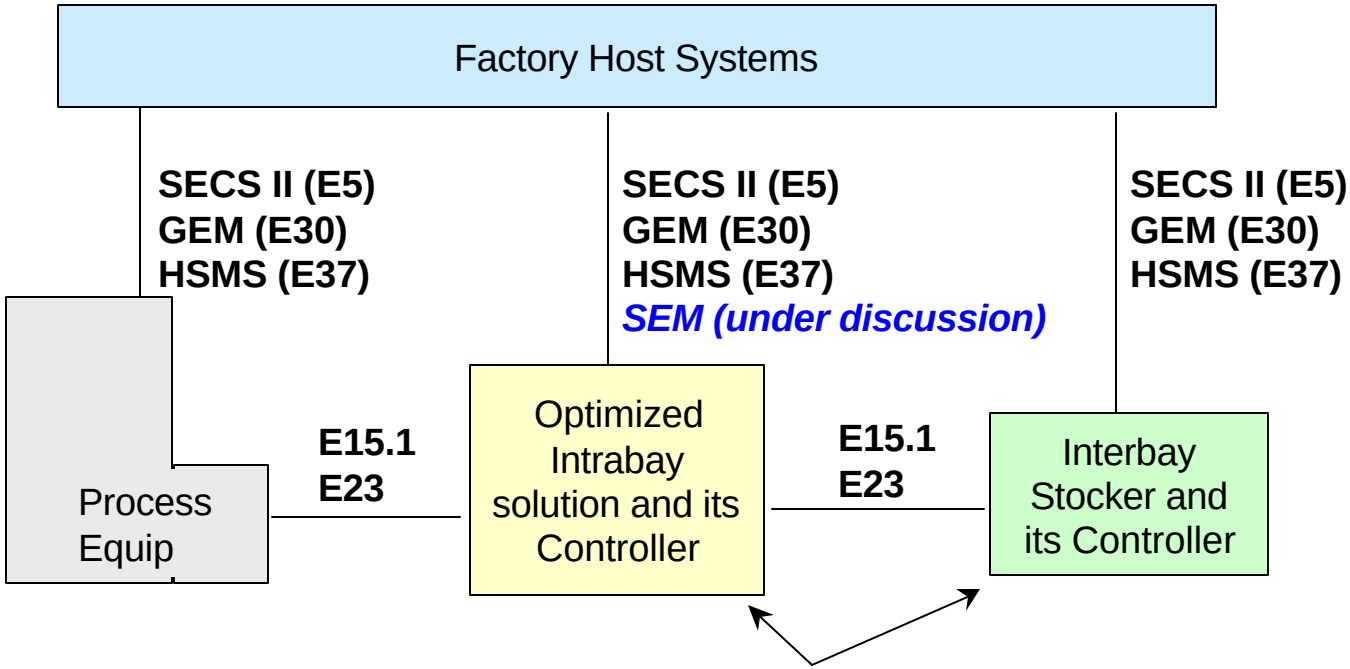
Important CIM Standards

- **In order to realize the desired bay throughput, layout flexibility and cost effectiveness of CIM systems, the device manufacturers want to ensure the best Intrabay solution for each bay. This implies multiple Intrabay solutions (best in class for Stocker, OHT, AGV or RGV) and their respective suppliers for a factory. Appropriate Controls architectures including standardization of physical and communication interfaces are a must to realize this vision.**



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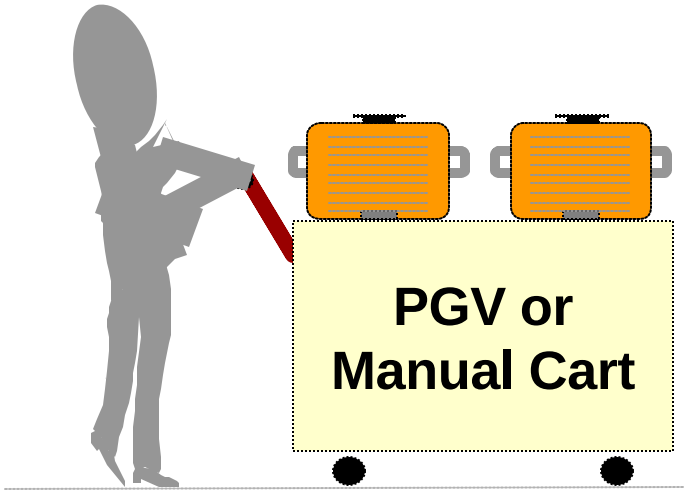
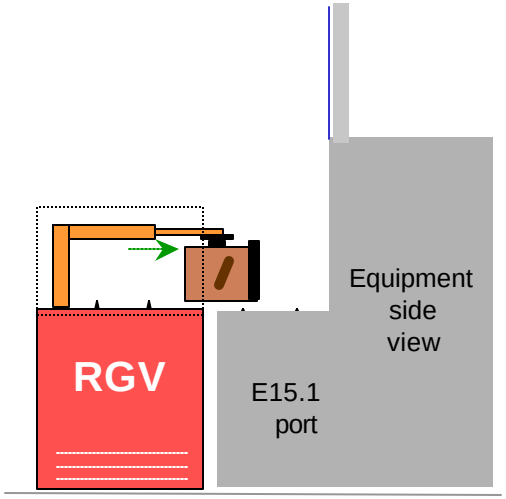
Need to manage the Transition

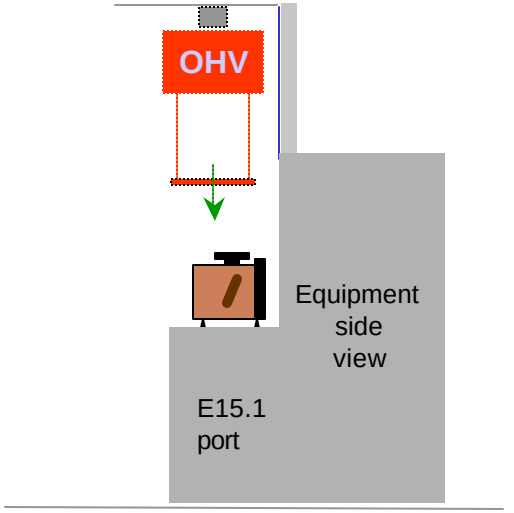
Start-Up



High Volume



Final selection is based on Intrabay technology readiness and production equipment maturity



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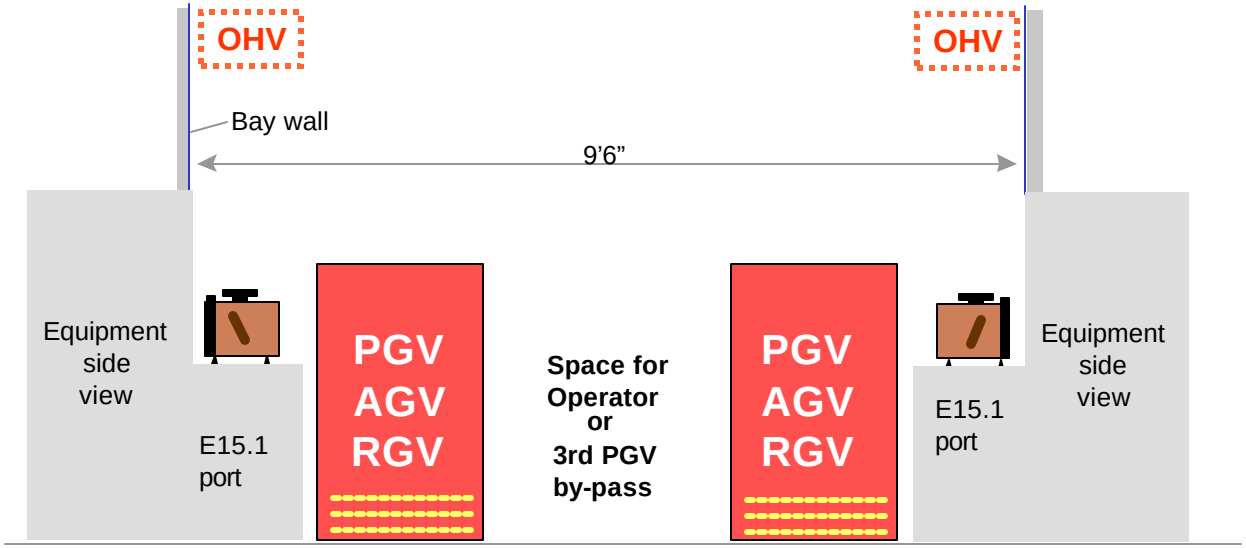
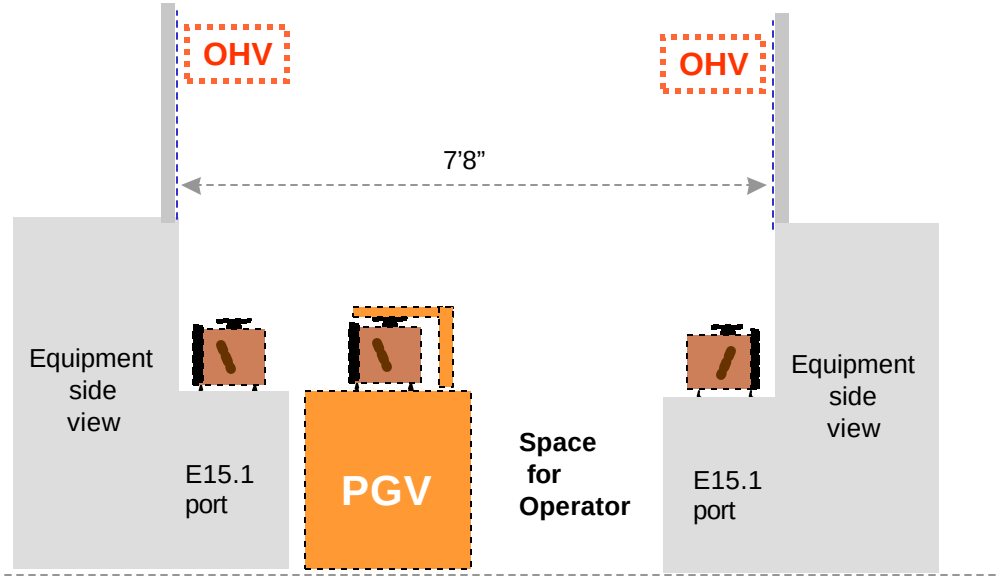
Bay width transition for OHV



Low Risk

This bay-width permits RGV, PGV and OHV to be functional



High Risk

Here a single PGV is used as manual backup for OHV system. RGV not feasible with this approach. Also PGV does not have extended throughput capability.

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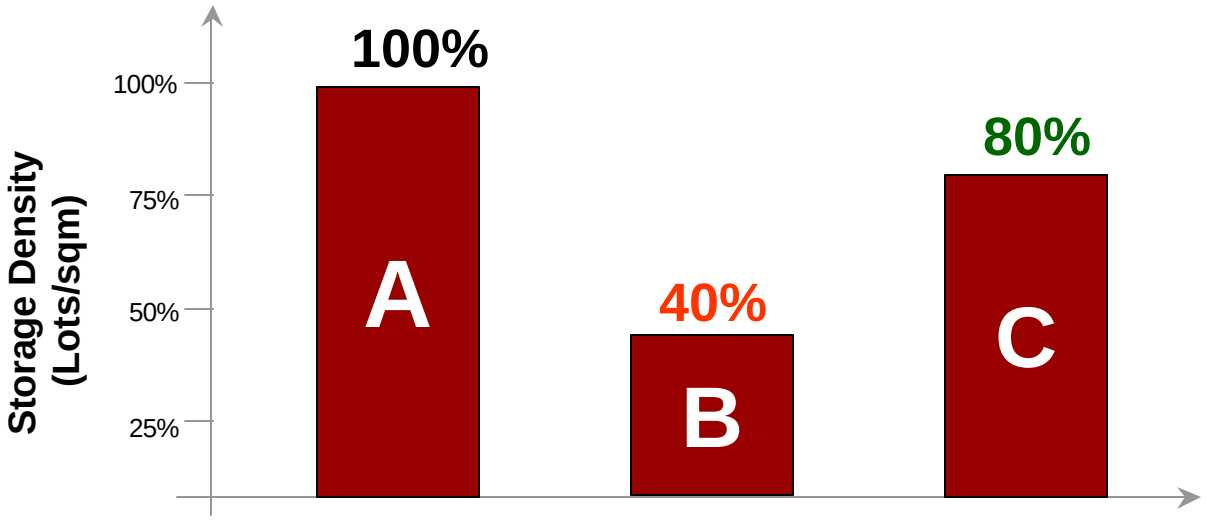
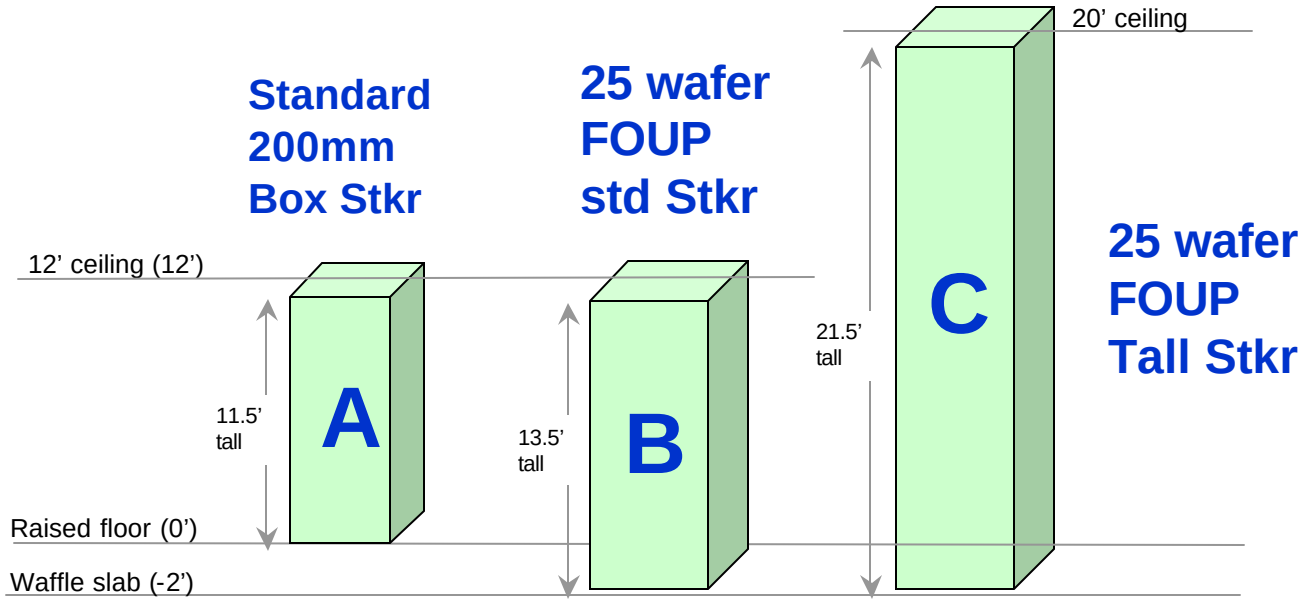
Why Tall Stockers ?





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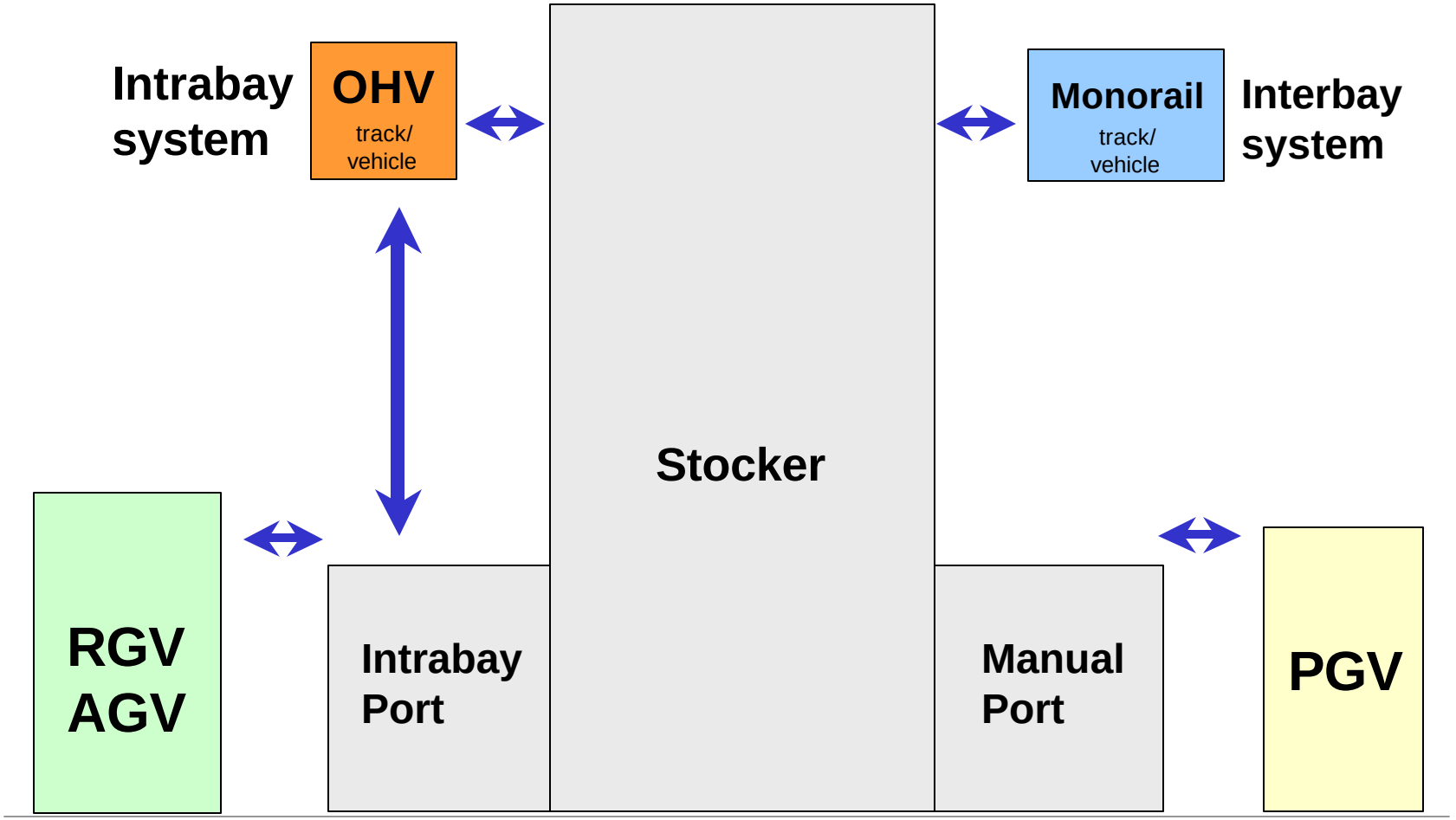
Interfaces required for AMHS Mix and Match



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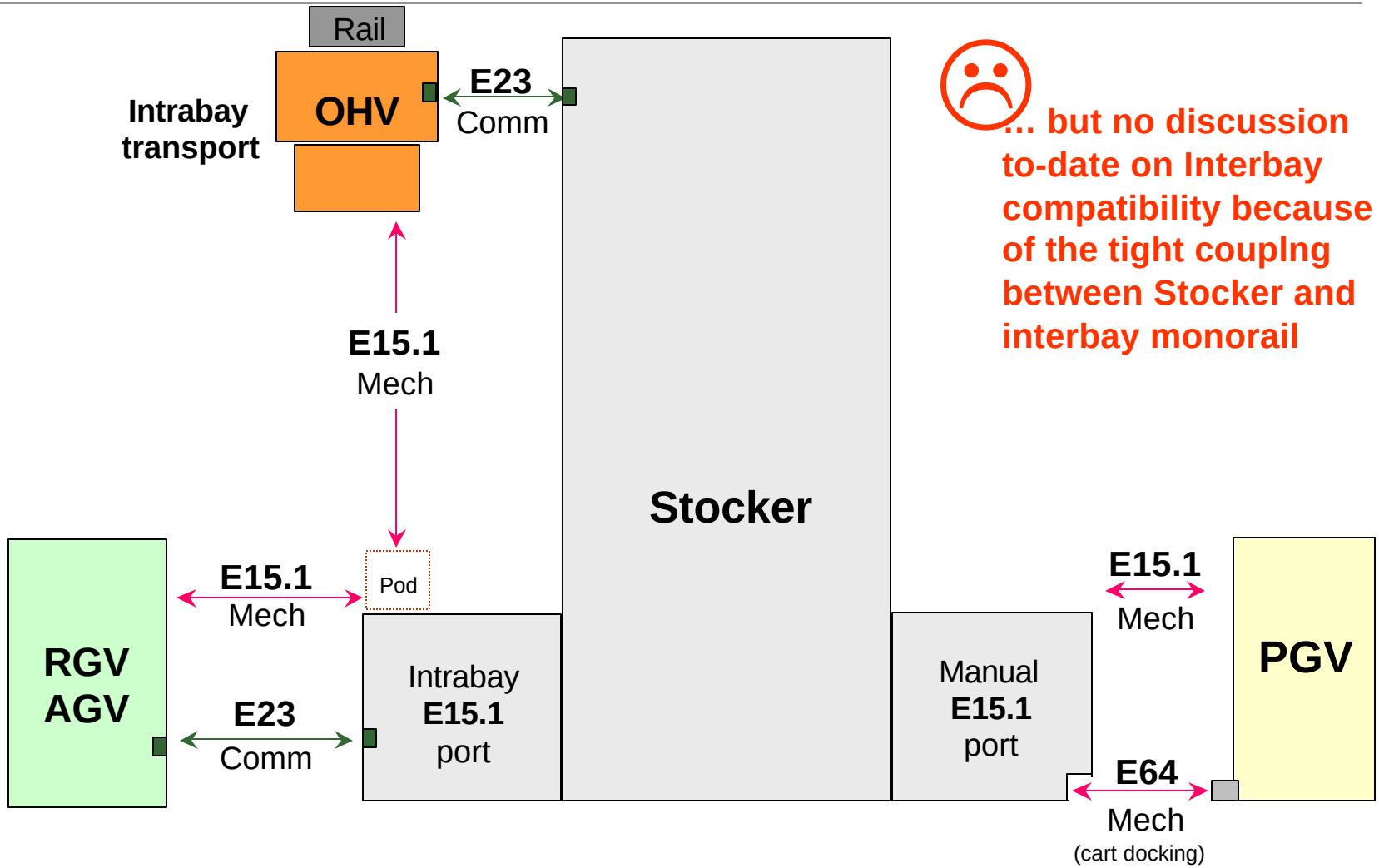
Intrabay componenets are fully inter-operable



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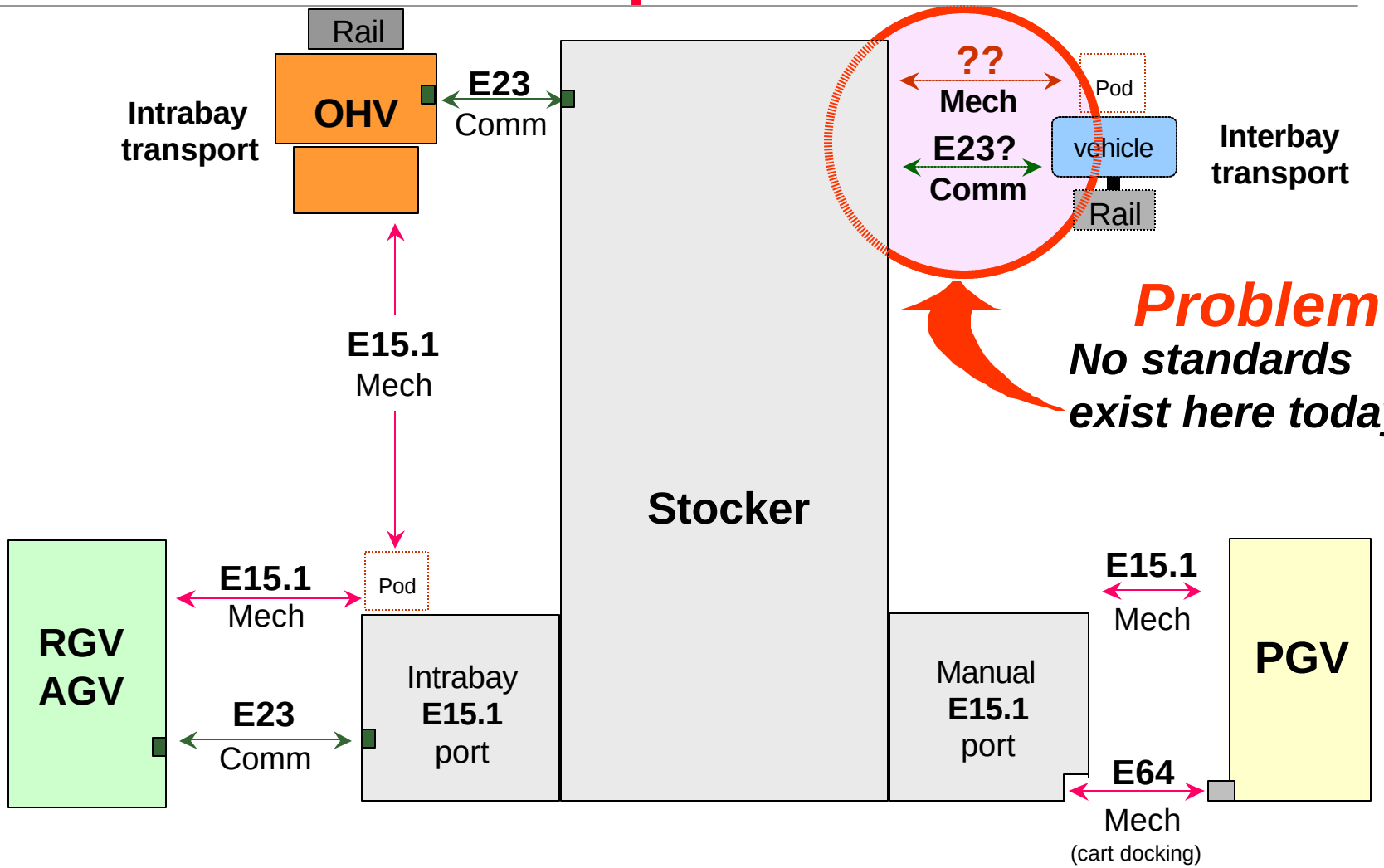
Complete AMHS Mix and Match:

Inter-operability of Interbay components is required



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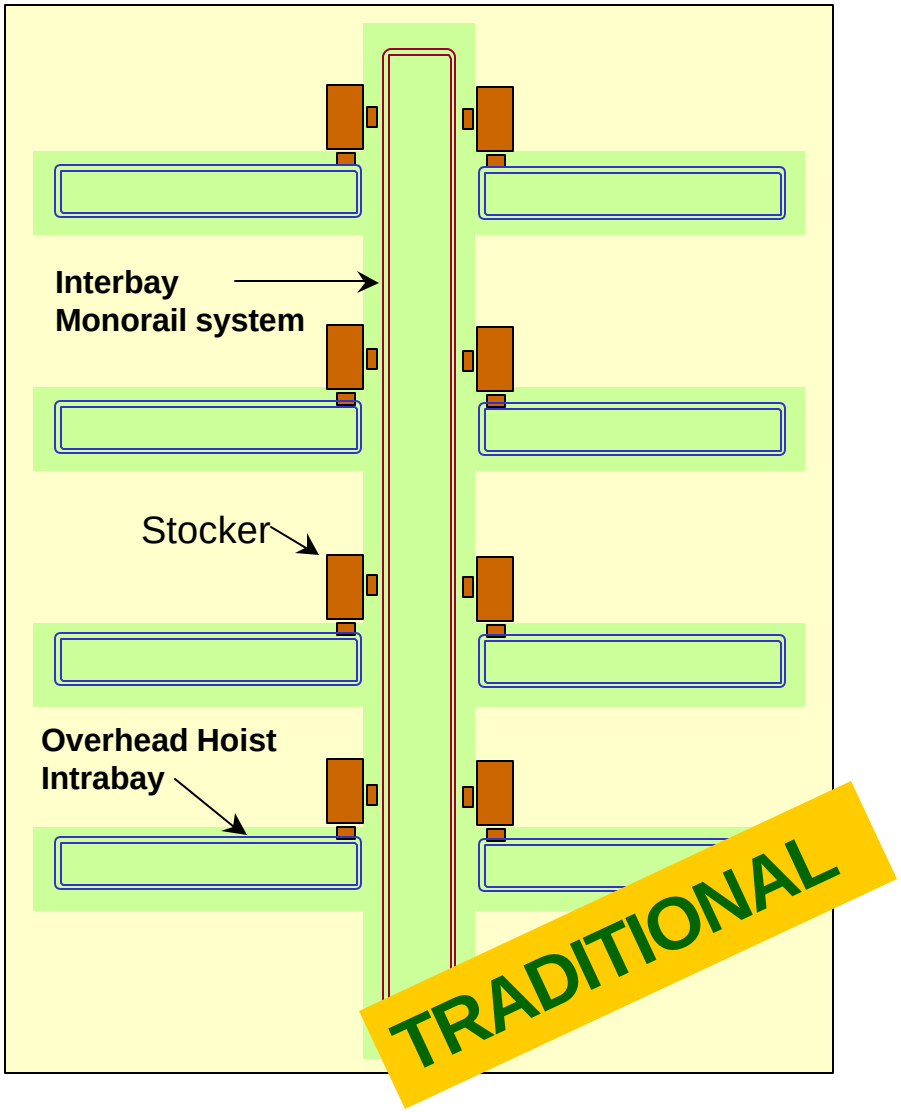
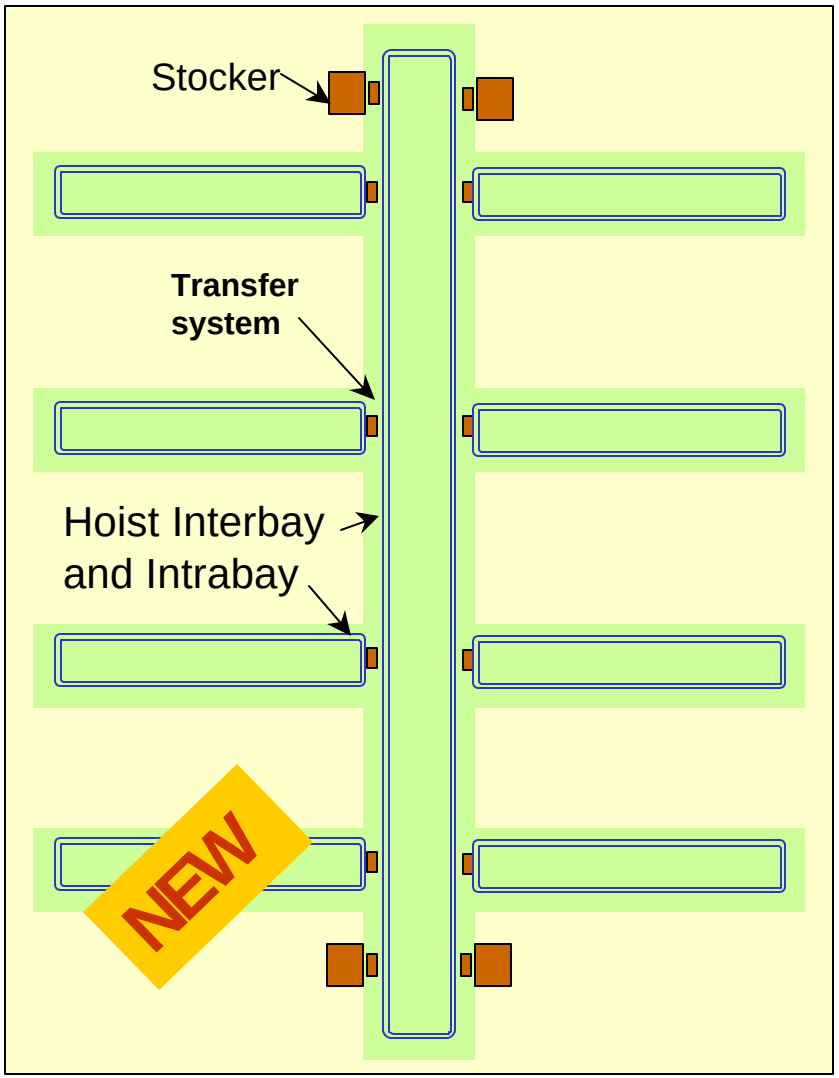
Combine Interbay and Intrabay Transport systems?

Separate Interbay and Intrabay



Combined Interbay and Intrabay



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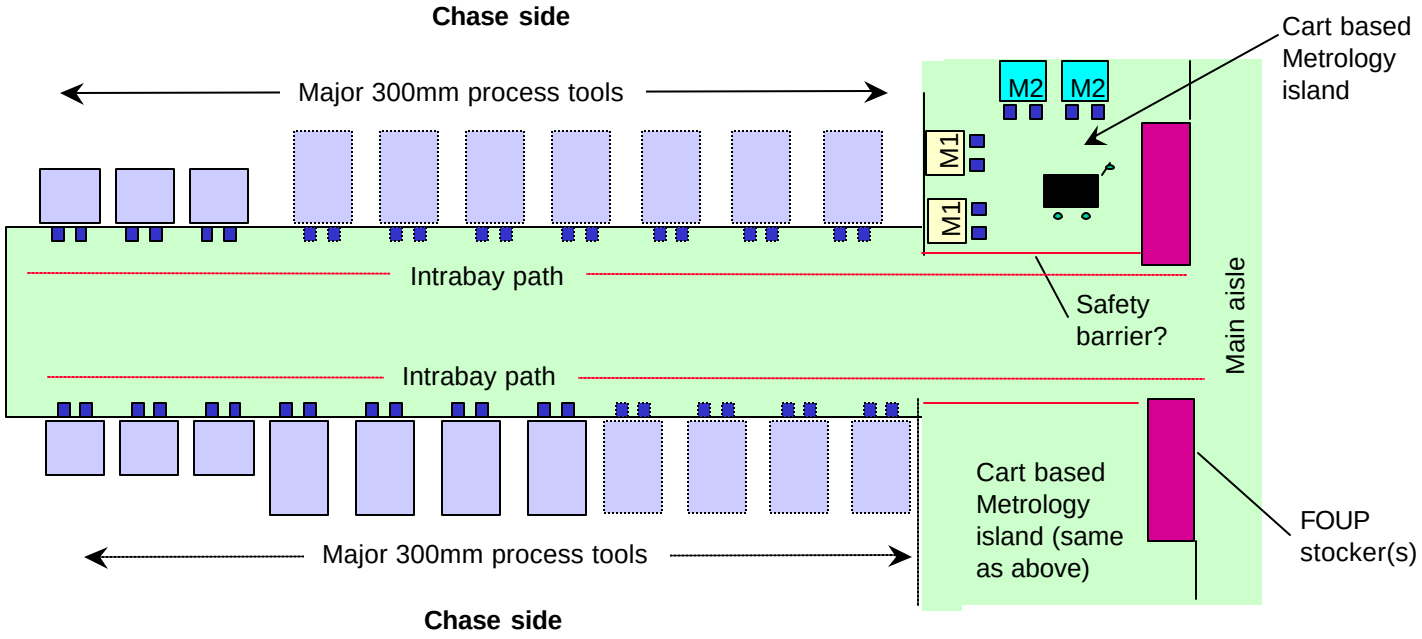
Metrology Layout Options

Case 1: Adjacent Metrology area for each bay



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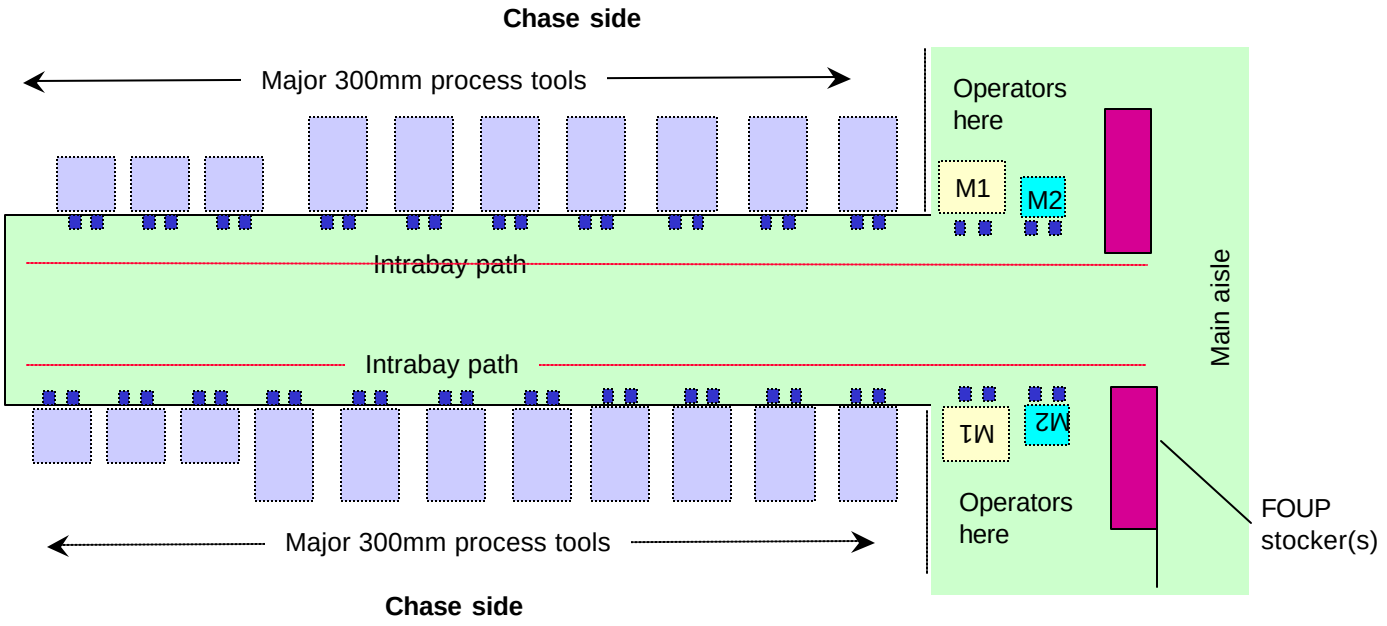
Metrology Layout Options … contd

Case 2: **In-line Metrology area mixed with major process equipment in each bay**



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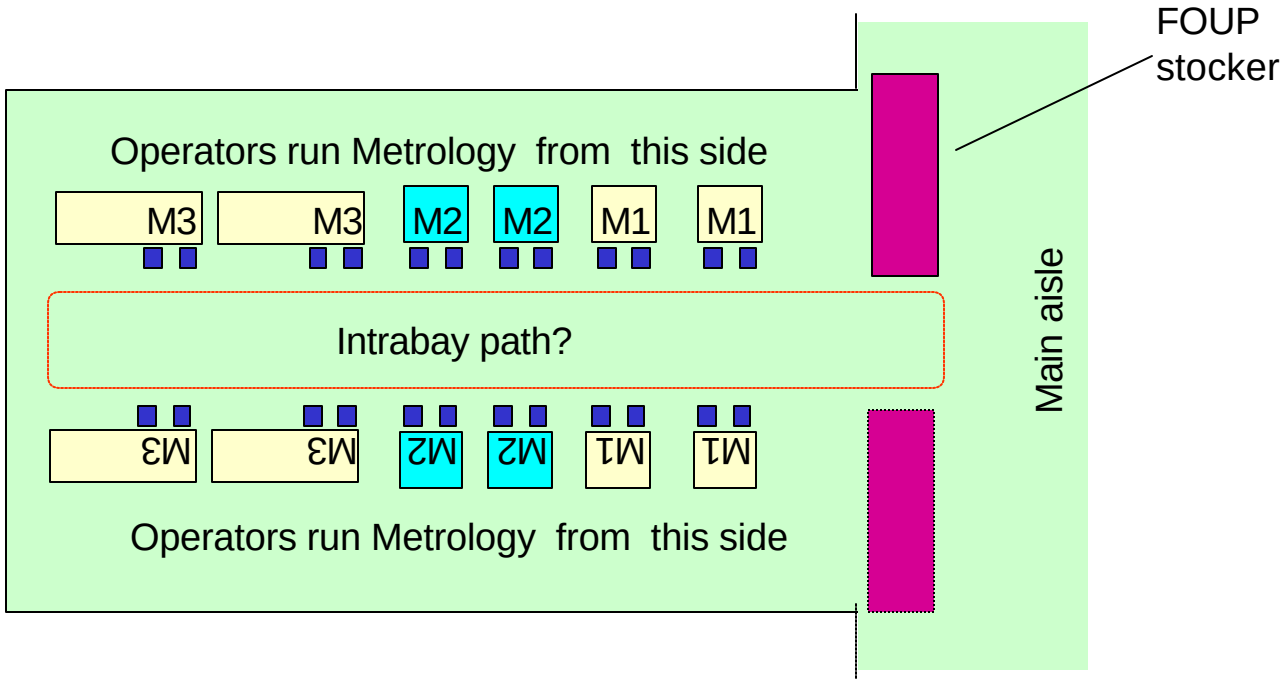
Metrology Layout Options … contd

Case 3: **Dedicated Metrology area laid out for Intrabay flexibility**



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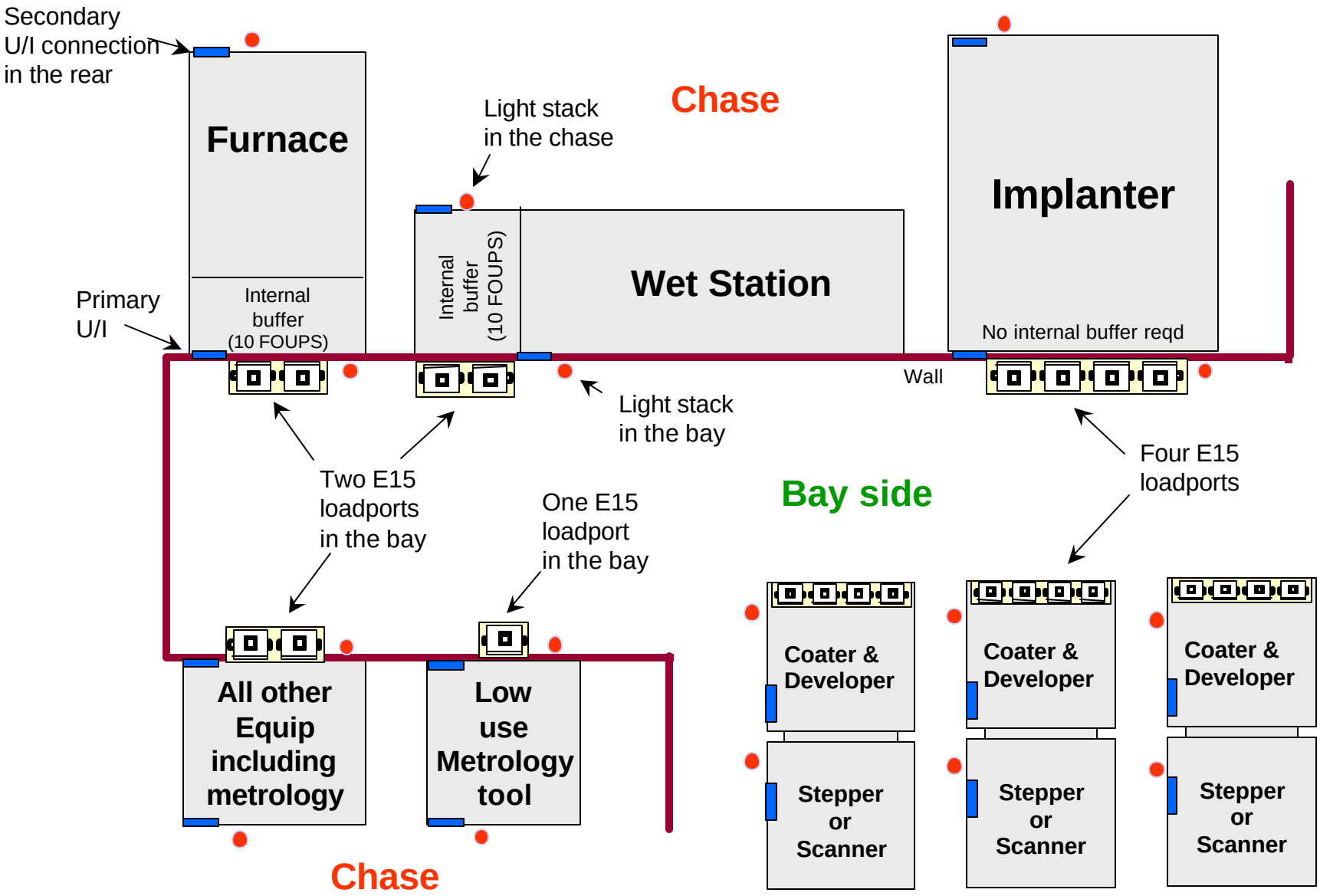
Equipment configuration for Buffering



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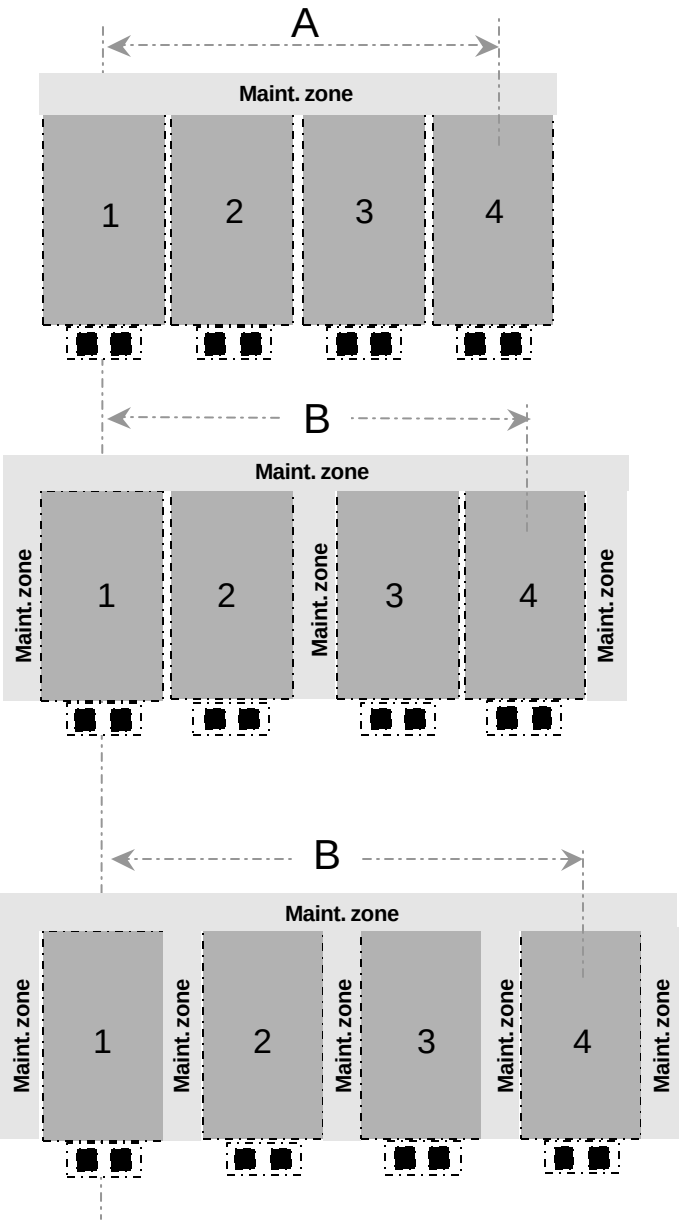
Buffering Summary

Equipment type	# of E15.1 loadports	Addtl internally buffered lots
Vertical Diffusion Furnace	2	16
High Speed Wet Station	2	10
Implanter	4	No need
Coater/Developer Track	4	No need
All other tools, including in-line Metro tools	2	No need
Low use (off-line) Metrology tools	1	No need

Dense Packing of Equipment in a Bay



Case A
Most dense packing

Case C
Least dense packing

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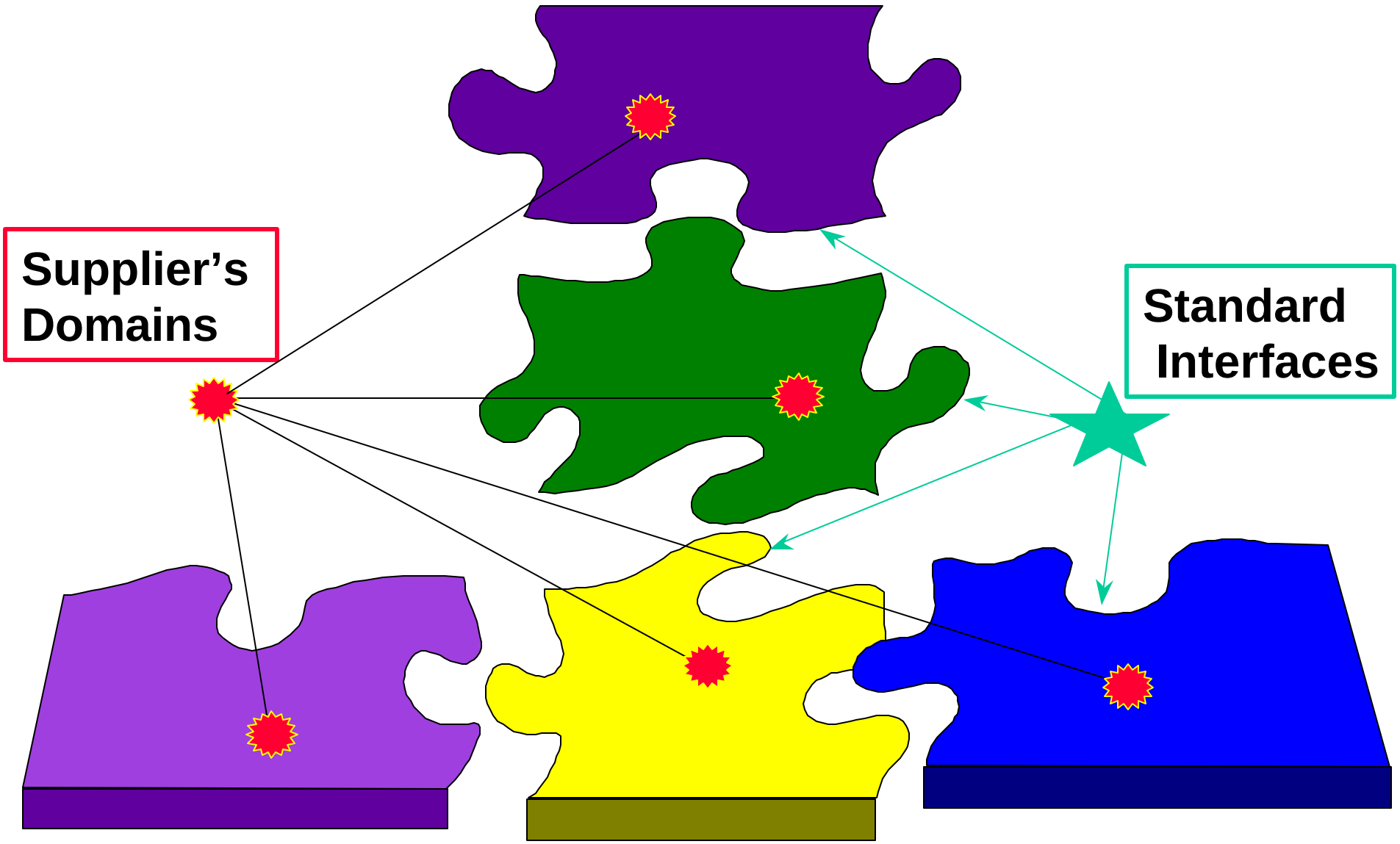
New Paradigms to Factory Layouts

Layouts driven by business models and flexibility:

- **Traditional central spine layout or the PCS Forum's Windmill Fab?**
- **Do we combine Interbay and Intrabay system into one large system?**
- **Do we need bay walls or not?**

Factory Layout = business driven interconnection of standard interfaces



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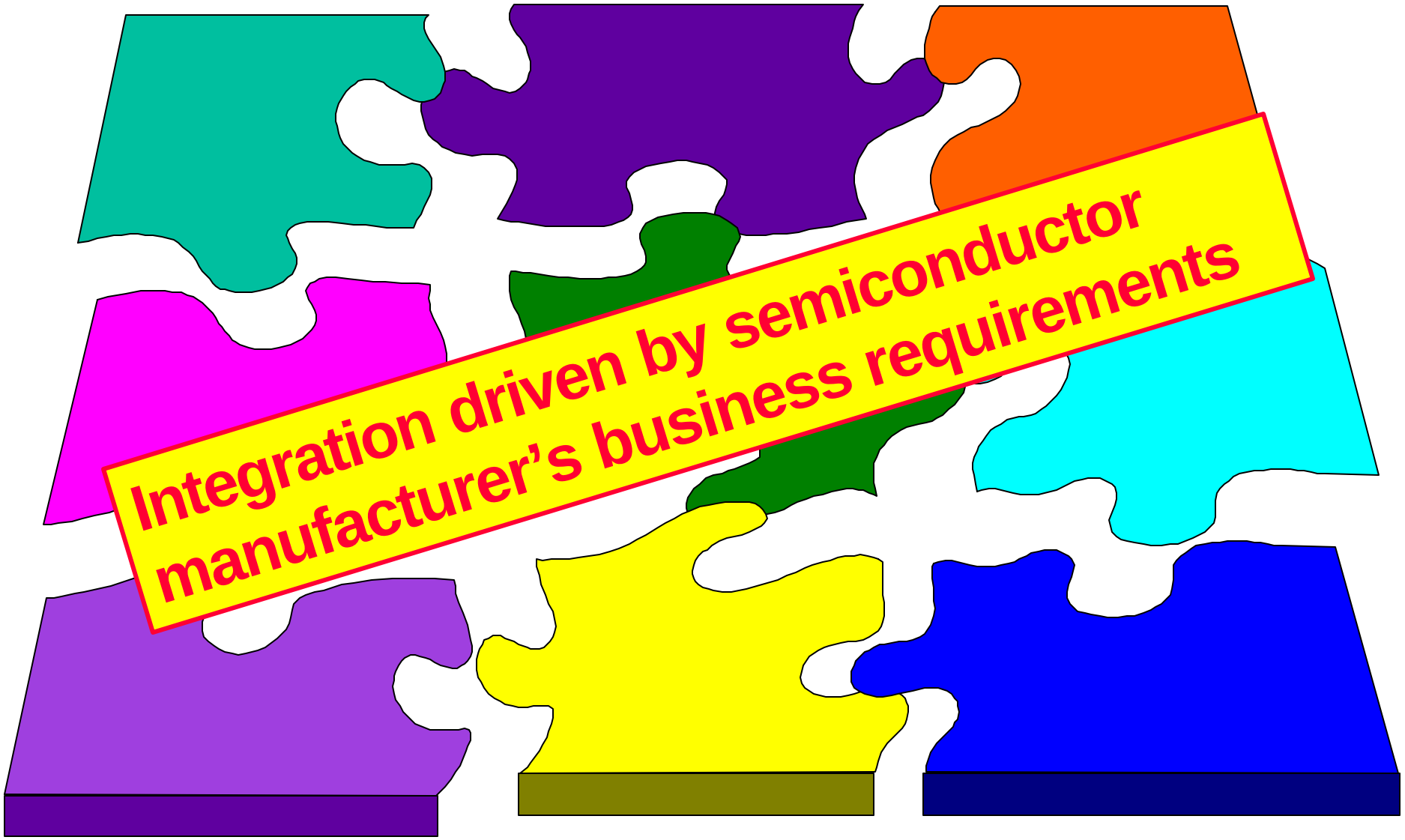
Factory Layout = business driven interconnection of standard interfaces



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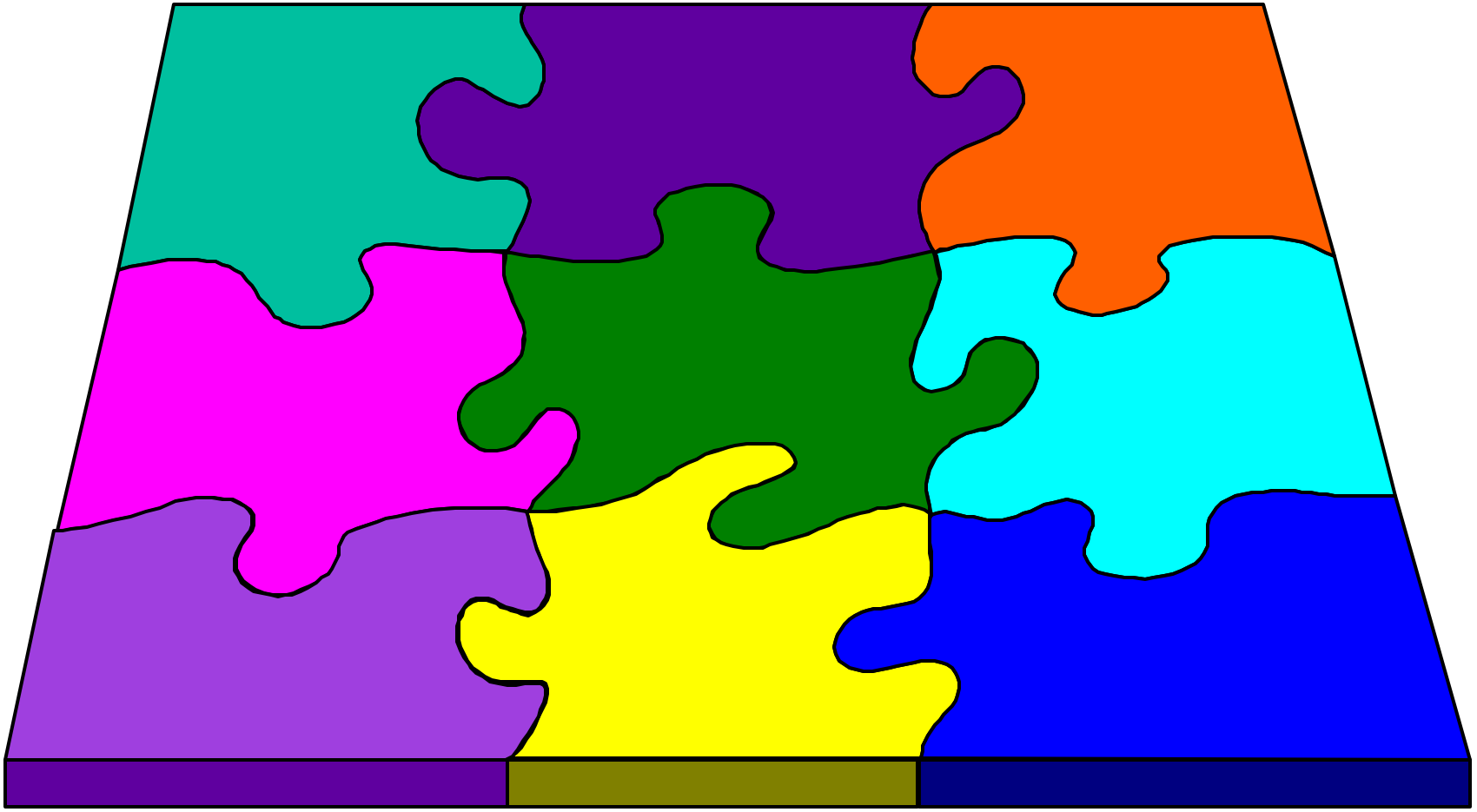
Factory Layout = business driven interconnection of standard interfaces



Layout Evaluation Planning

Business Models

- High Volume fabs
- Q-TAT fabs
- Mixed products fabs

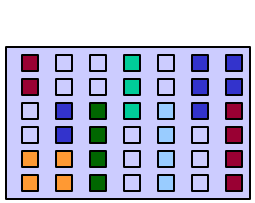
drives

Unique requirements

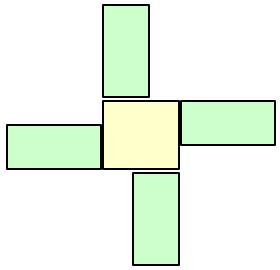
drives

Customer requirements

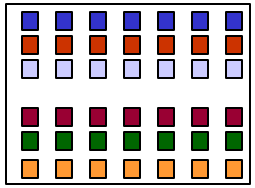
Will it drive different Layouts?



Layout A



Layout B

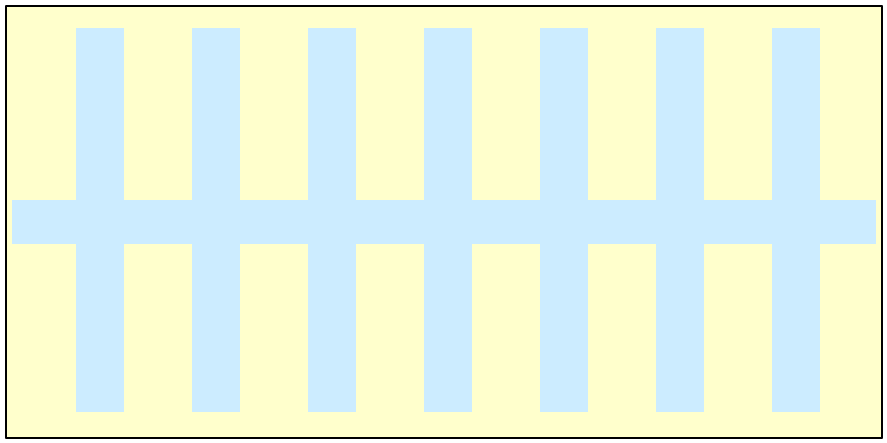


Layout C

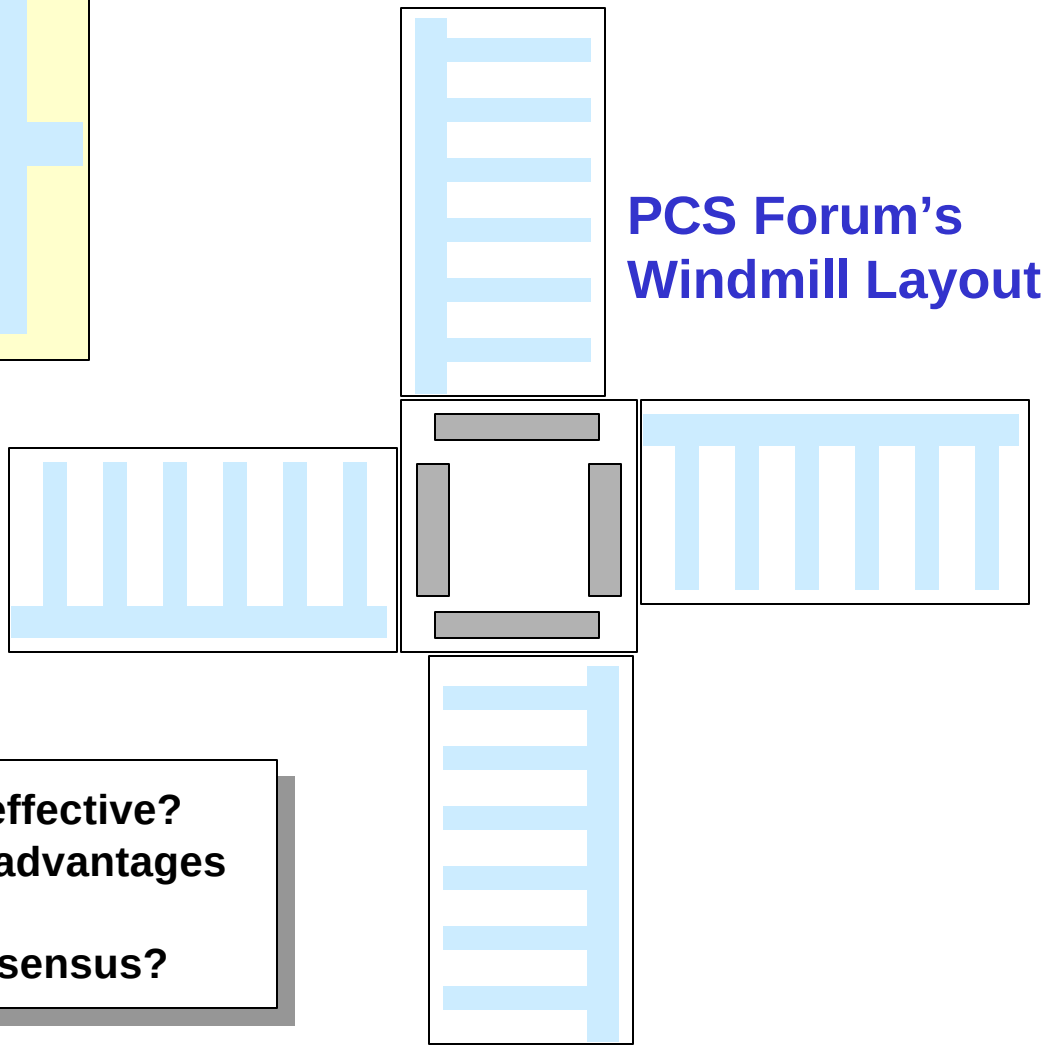
Questions requiring answers:

1. **Need to understand which solutions are feasible and which can be implemented.**
2. **Will these layouts be flexible and cost effective if business models change?**
3. **Can we do something up-front now to the layout that will minimize disruption later on when these changes occur?**

Traditional Spine Layout or Windmill Fab?



Spine Layout



PCS Forum's Windmill Layout

- Which is more efficient and cost effective?
- Does one layout have singificant advantages or disadvantages?
- Will the Windmill Layout gain consensus?

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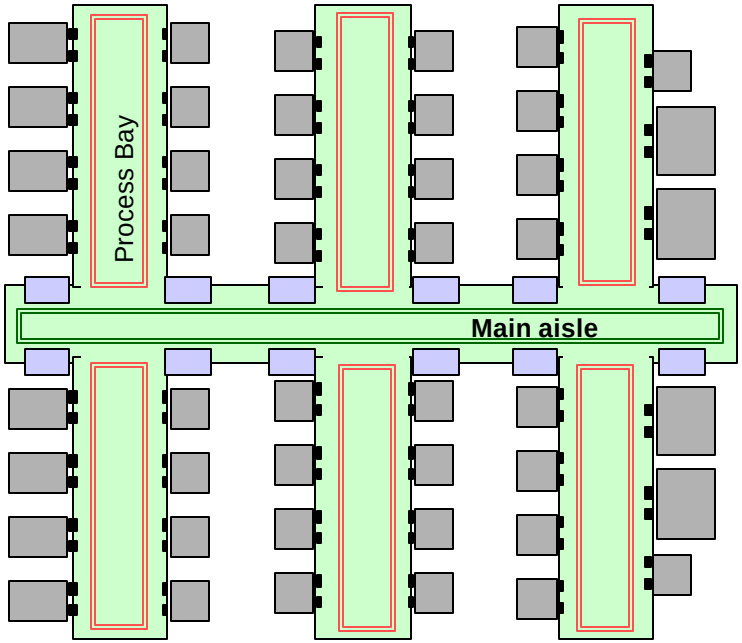
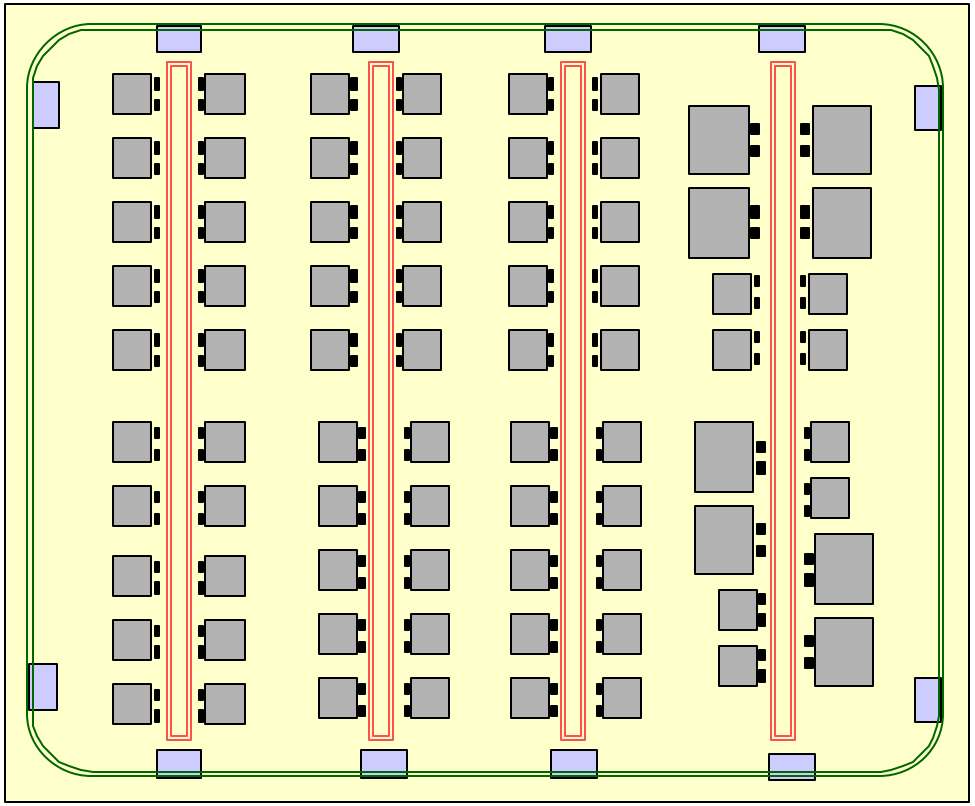
Layout Options without Bay Walls





- Which is a more efficient Transportation system ?
- Will this lead to better equipment packing density?
- Will this result in improved human factors ?

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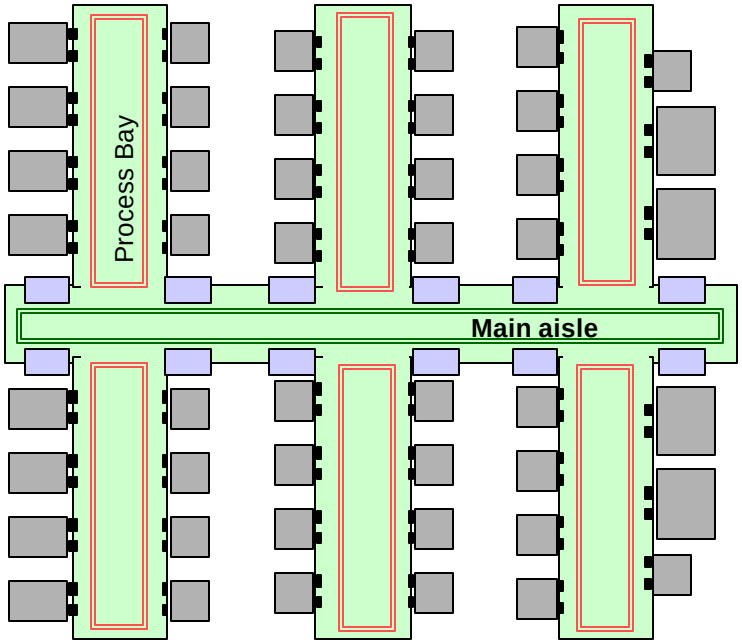
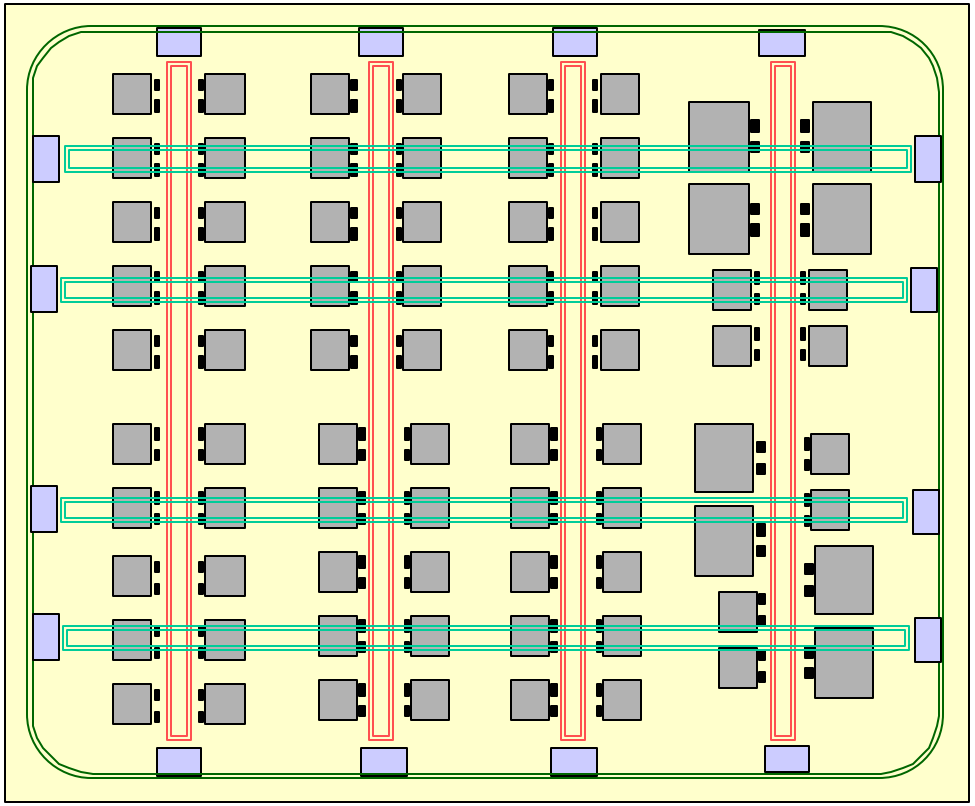
Layout Options without Bay Walls





- Which is a more efficient Transportation system ?
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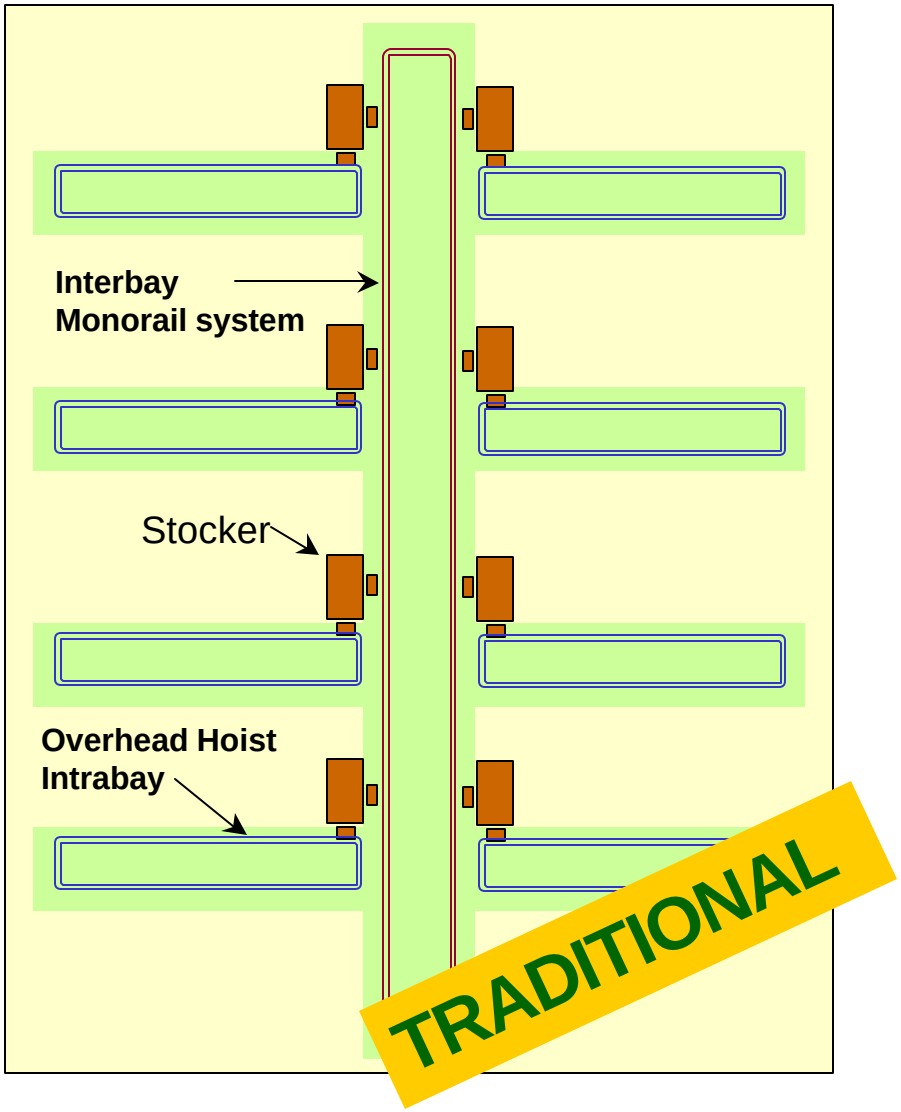
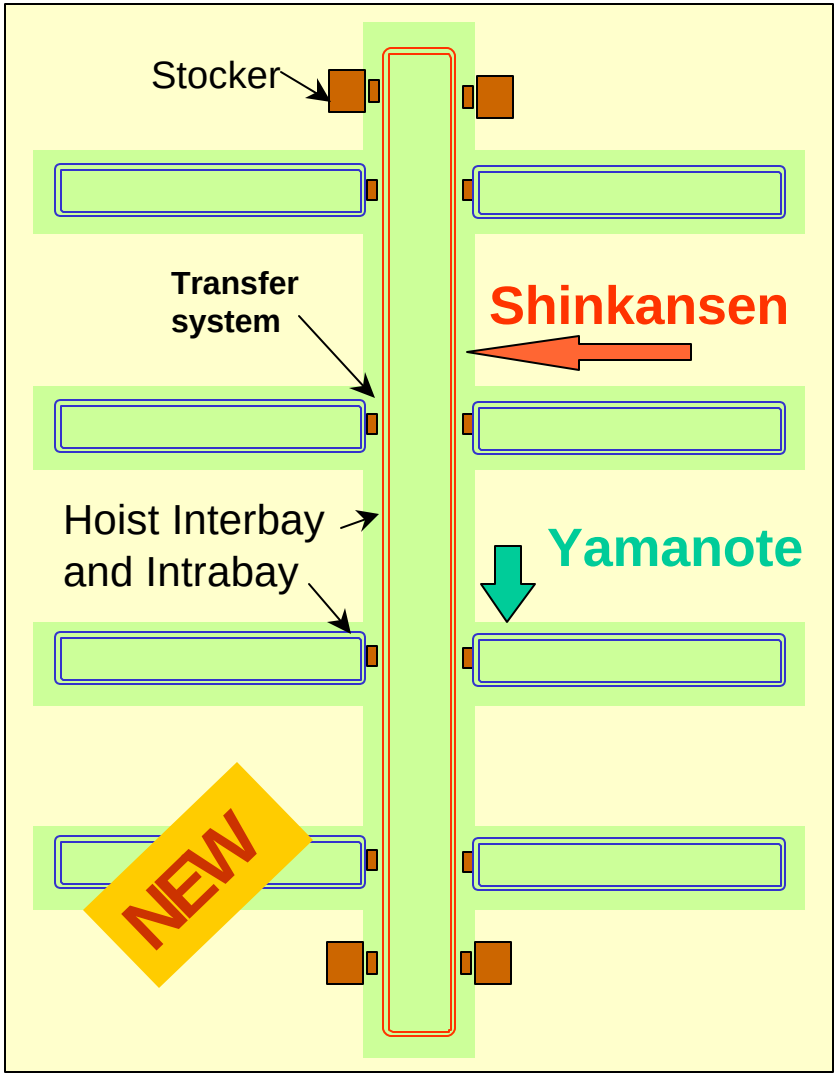
Combining Interbay and Intrabay Transport Systems Makes a Very Efficient AMHS

Separate Interbay and Intrabay



Combined Interbay and Intrabay



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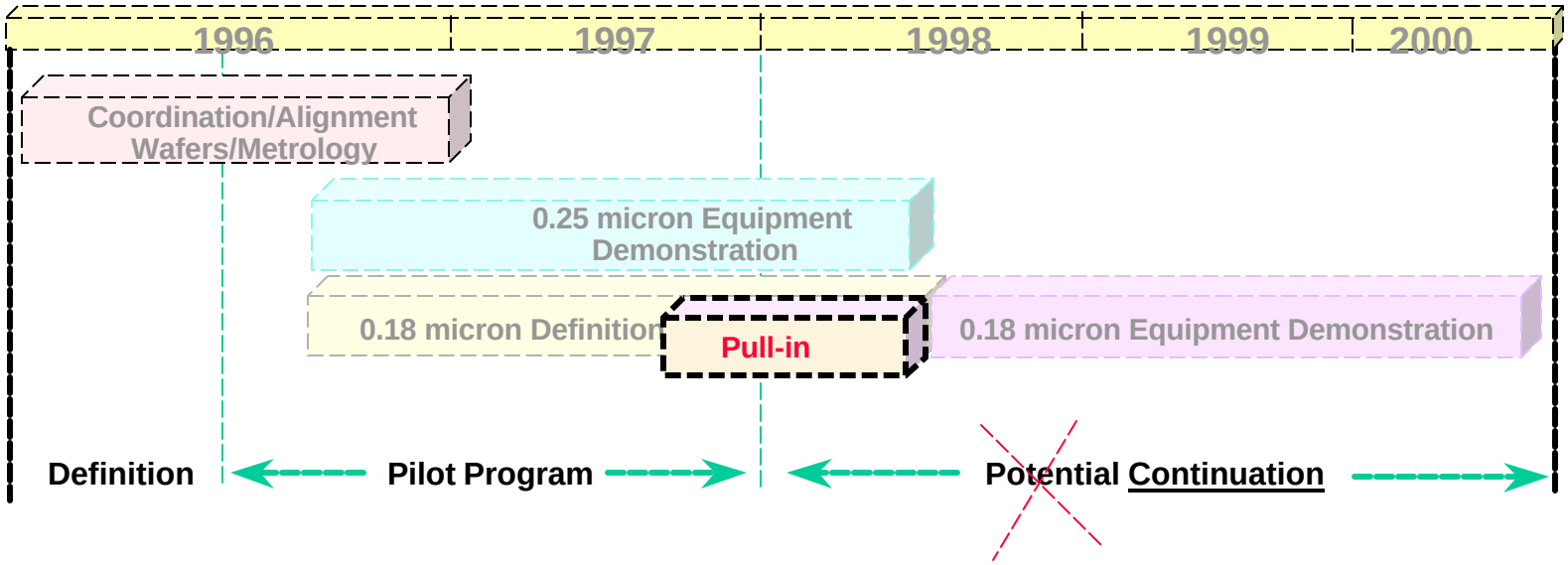
I300I Original Time Table

- International consortium, 18 month pilot program, with budget of $26M



Proposed Focus Areas

- Standards: Defined “In Time”
- Device company consensus on schedule, demo methods and metrics
- Work with suppliers on standard test and processing capability
- Metrology capability and wafers for early development
- Validate standard demonstrations of targeted 0.25 micron equipment
- End 0.25 micron / begin 0.18 micron tool demonstrations in mid-1998

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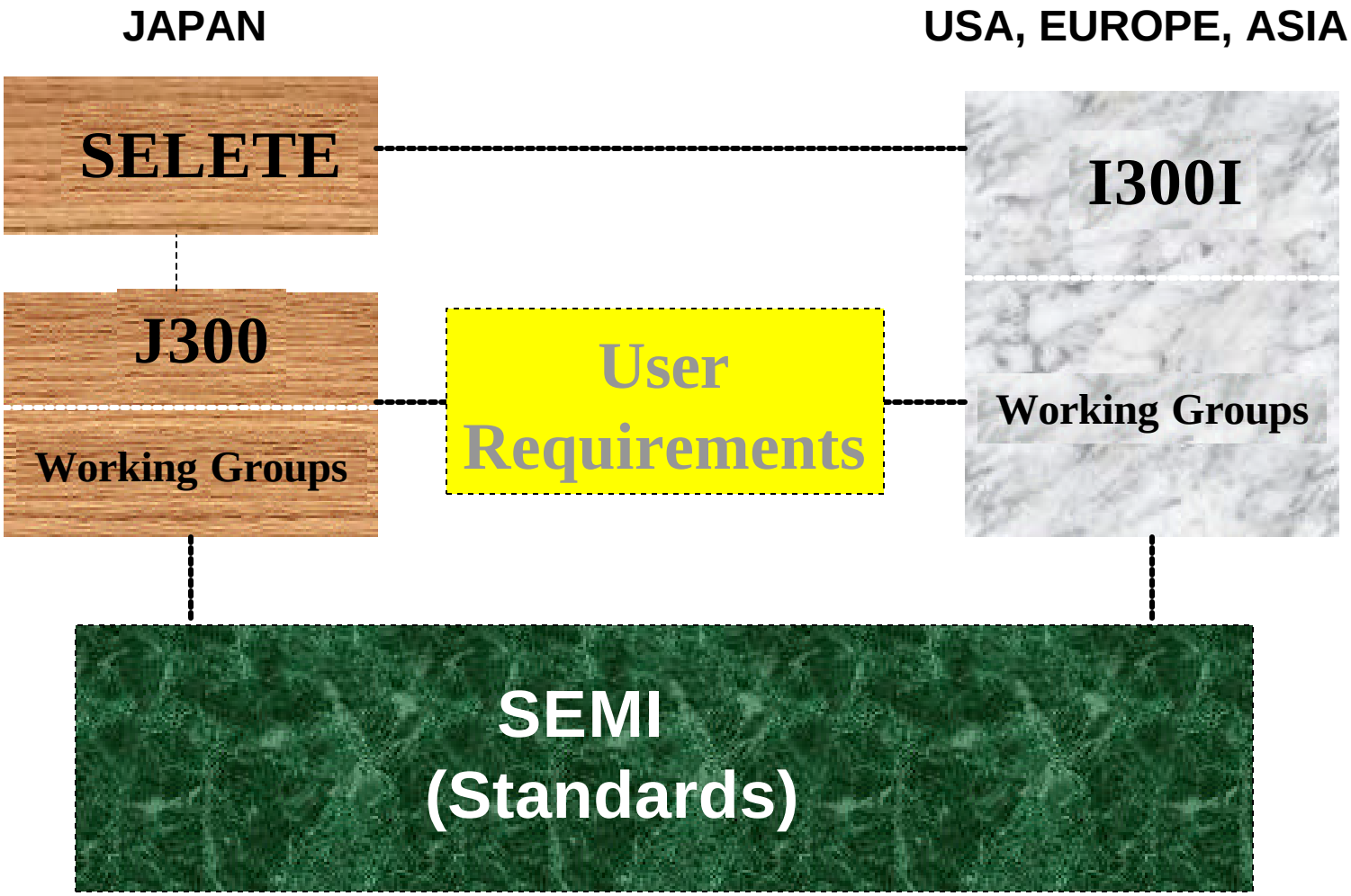
Cooperation of Consortia



Conclusions

- The outlook of the Semiconductor Industry towards the 21st century is still very promising
- The 300mm wafer conversion offers an opportunity to correct some of the errors of the past
- Standards provide a mechanism for integrating the different elements of the factory cost-effectively
- Relative quipment cost and relative footprint goals have been set with respect to 200mm wafer equipment of equal wafer throughput
- Load port standardization, consistent with PGV, AGV, RGV,and OHV intrabay solutions for both FOUP and Open Cassette, has been established

Conclusions

- OHT offers the opportunity of combining intrabay and interbay material movement systems
- Adoption of minienvironment (FOUP) provides new options for factory layout
- Taller stockers are required to maximize storage efficiency of 300mm wafer carriers
- Equipment buffering requirements have been established. In most cases two E15.1 load ports are sufficient
- Metrology equipment needs to be carefully included as part of the factory layout

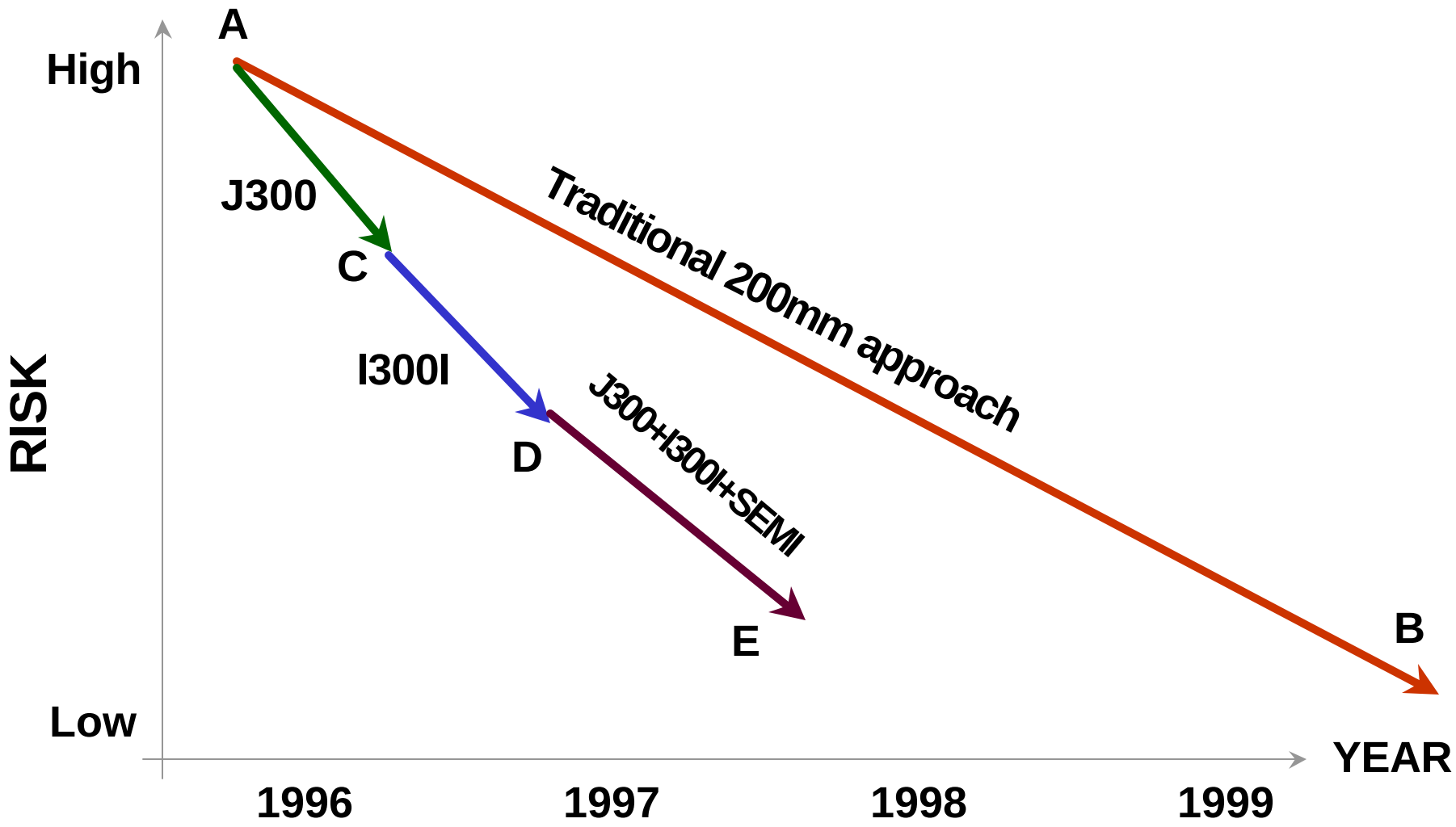
Conclusions

- Complete inter-operability of material handling and storage components dictates the adoption of a CIM architecture and new standards consistent with this requirement.
- Global cooperation is effective in accelerating program definition and execution
- Joint activities of J300, I300I, and SEMI are succesfully continuing
- Joint activities of Selete and I300I are successfully continuing

Conclusions

- Complete inter-operability of material handling and storage components dictates the adoption of a CIM architecture and new standards consistent with this requirement (I300I/J300 CIM Working Group).
- Global cooperation is effective in accelerating program definition and execution
- Joint activities of J300, I300I, and SEMI are succesfully continuing
- Joint activities of Selete and I300I are successfully continuing

Risk Reduction using Global Participation and Standardization



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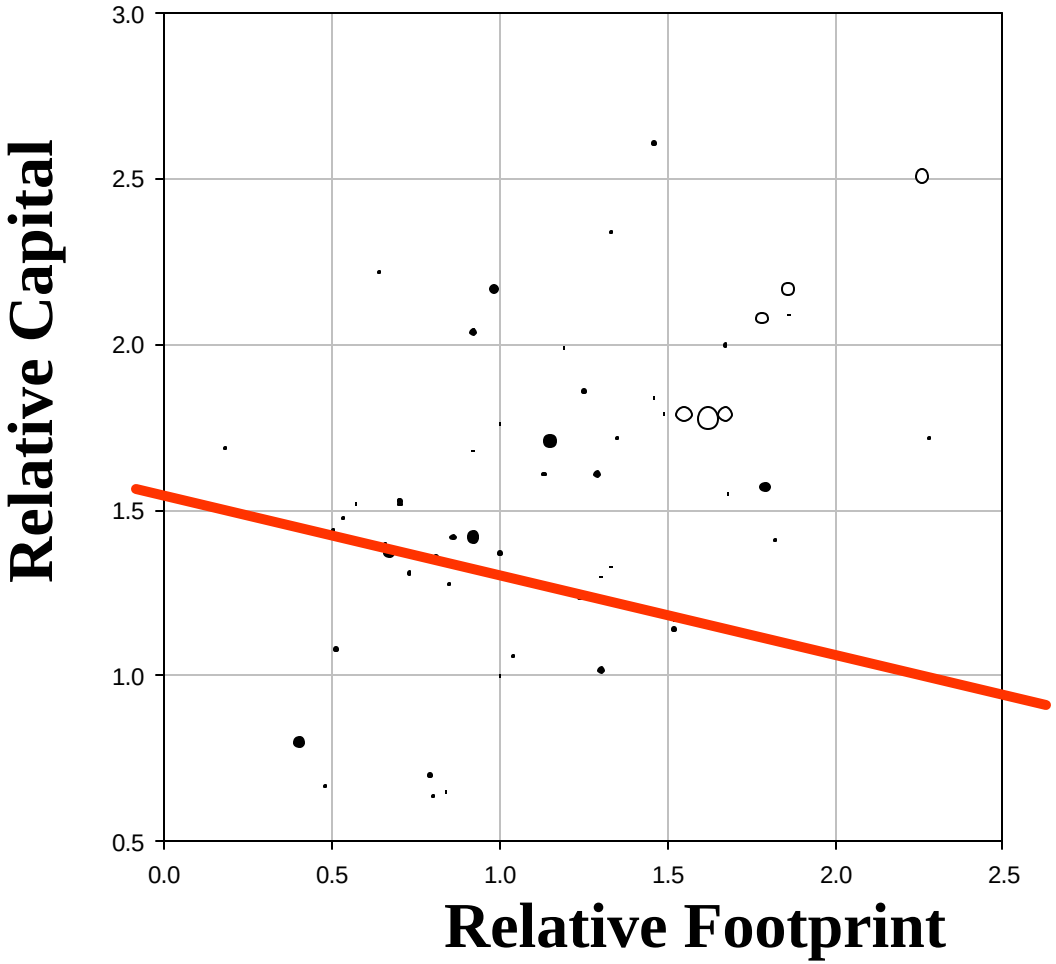
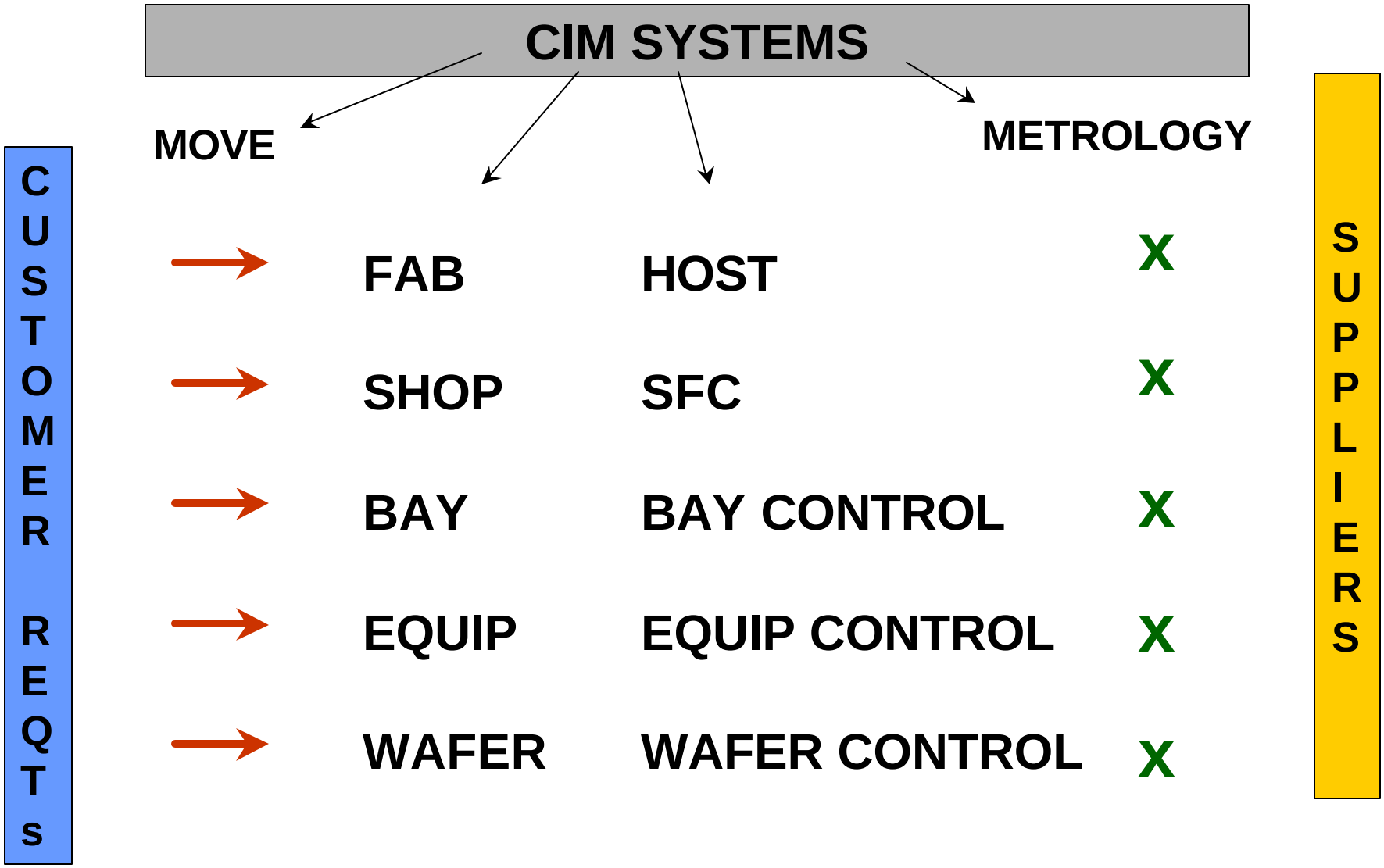
Early Productivity Scaling Factors for Tools in a 0.18 μm Logic Process Flow



D.Seligson

P.Gargini&D.Pillai

Prioritized Testing FOR 1998



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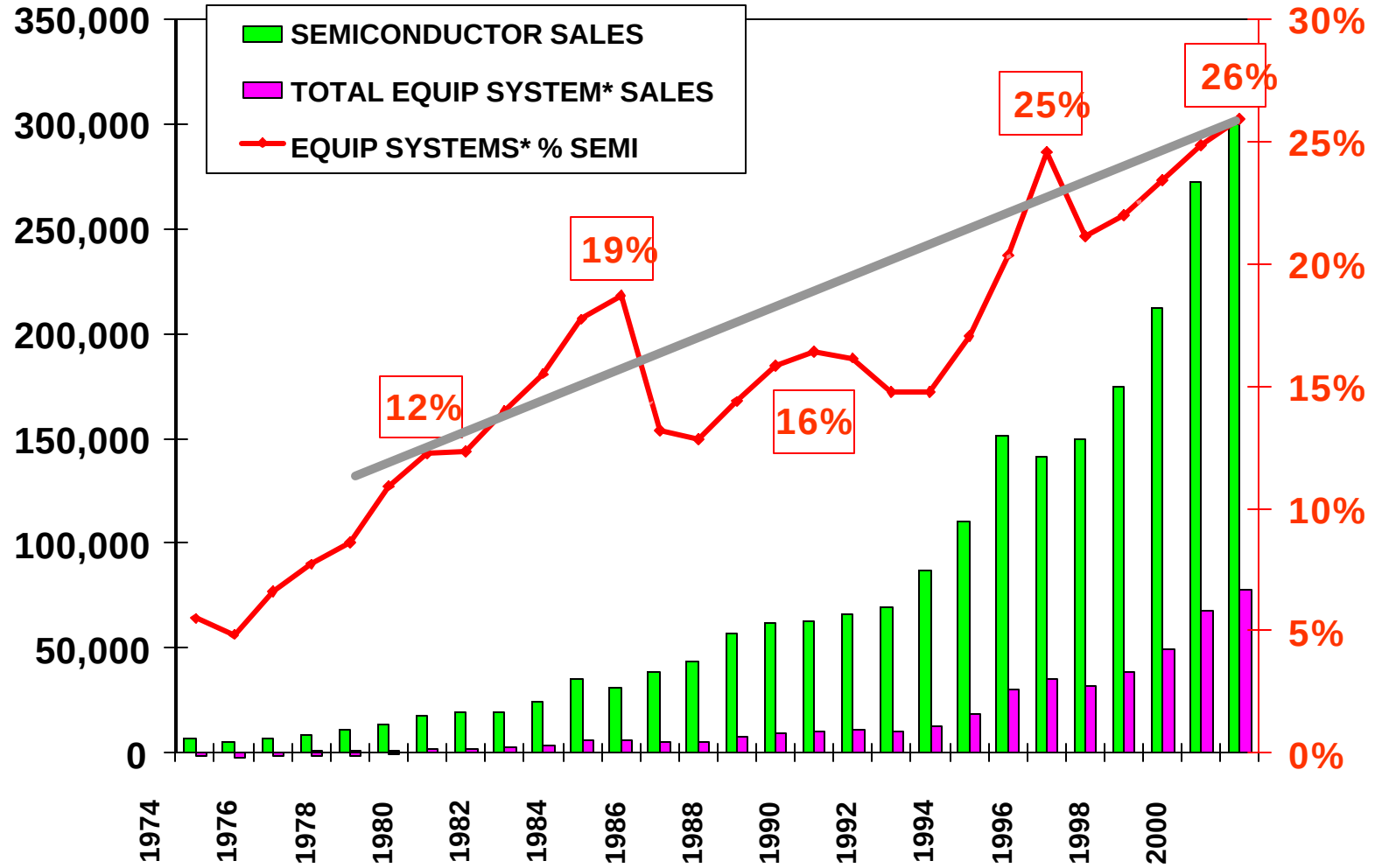
Total Equipment Cost



Source: VLSI Research Inc. July 1997

* Includes Spares and Service

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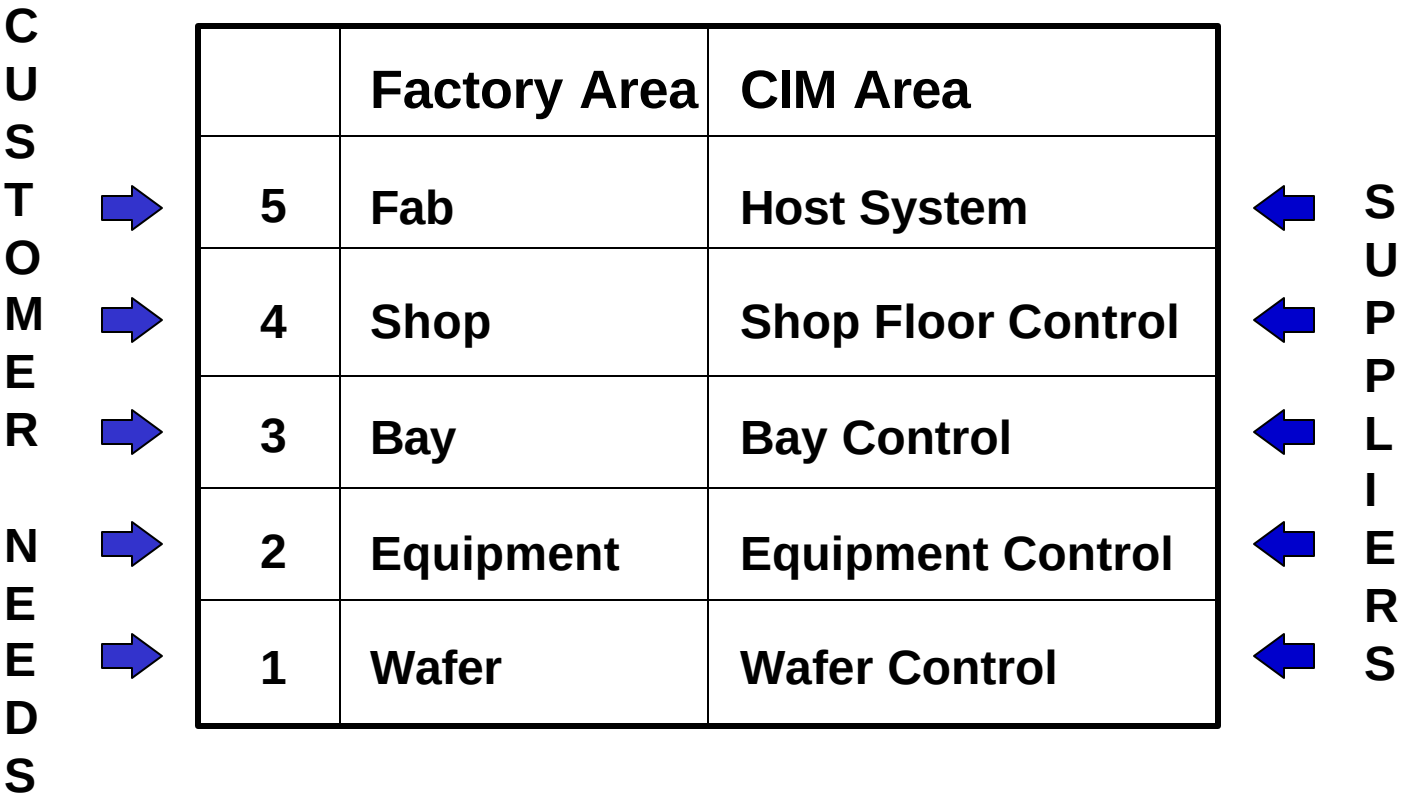
Standards Strategy for Semiconductor Industry



	Factory Area	CIM Area
5	Fab	Host System
4	Shop	Shop Floor Control
3	Bay	Bay Control
2	Equipment	Equipment Control
1	Wafer	Wafer Control

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